2.0 Baseline Conditions

Contents:

2.1 Introduction

This section discusses baseline conditions in the White River and its tributaries, and the sources of pollution affecting water quality in Marion County. It summarizes the city's characterization of the existing wastewater collection and treatment system. It describes how background and upstream sources, CSOs, industrial discharges, and non-point source pollution combine to cause water quality problems in Indianapolis.

Information on the combined sewer system is drawn in part from the following documents and sources:

- "CSO Operational Plan" (CSOOP) (Department of Public Works (DPW) - Indianapolis Clean Stream Team (ICST), May 2003)
- "Stream Reach Characterization and Evaluation Report" (SRCER) (DPW-ICST, June 2003)
- Sewer system computer modeling
- White River, Fall Creek, Pleasant Run and Bean Creek Total Maximum Daily Load (TMDL) Studies (Indiana Department of Environmental Management (IDEM), 2003)

Information on Marion County water quality and pollution sources is drawn from a variety of past and ongoing studies of Indianapolis waterways. Ongoing sewer and treatment plant capital projects are constantly improving the city's sewage treatment and collection system. For this report, unless noted otherwise, infrastructure and environmental conditions are presented as they existed in December 2001, prior to major sewer and treatment system improvements.

Documenting the baseline and historic water quality and physical conditions in Marion County streams also will support the analysis and conclusions in the city's Use Attainability Analysis.

2.2 Stream Conditions in the White River Basin, Marion County, Indiana

The White River basin is part of the Mississippi River system and drains 11,349 square miles of central and southern Indiana (see **Figure 2-1**). Streamflows are typically highest in April and May and lowest in late summer and fall. Rainfall in the basin ranges from 40-48 inches per year. In winter and early spring, rains are generally long in duration, steady, and of mild intensity. Late spring and summer rains tend to be shorter in duration and more intense.

The population of the White River basin in 2000 was about 2.37 million (USGS, 2004), with about 36 percent living in Marion County (860,454 people). Approximately 70 percent of the land in the combined upper and lower White River basin is used for agriculture, including about 50 percent for cropland. Forests cover 22 percent of the land area, and urban and residential areas cover 7 percent. Land use in the Indianapolis area is primarily urban, and land use outside the Indianapolis area is primarily agricultural and forest. By 1876, 60 percent of the land in Marion County had been cleared of its original forests and, by 1999, less than 2 percent of land area contained natural forest structure and species composition (Brothers, 1994) (Mertz and Miller, 1999). As of 1997, approximately 11 percent of the land in Marion County was used for agriculture, according to the National Agricultural Statistics Service.

Indianapolis is located in the upper part of the White River watershed. White River flows from north to south through Indianapolis, entering Marion County just west of 96th Street and Allisonville Road and leaving near a location west of State Road 37 and south of Southport Road. Major tributaries flowing into the river include Fall Creek, Pogues Run, Pleasant Run, Bean Creek, Buck Creek, Eagle Creek, and Crooked Creek.

The White River and its two largest tributaries, Fall Creek and Eagle Creek, are the major sources of water for public and industrial supply for Indianapolis. Flows in Fall Creek are affected by Geist Reservoir, which has a storage capacity of 6.9 billion gallons at a reservoir elevation of 785 feet national geodetic vertical datum (NGVD). Flows in Eagle Creek are affected by Eagle Creek Reservoir, which has a storage capacity of 7.8 billion gallons at a reservoir eleva-

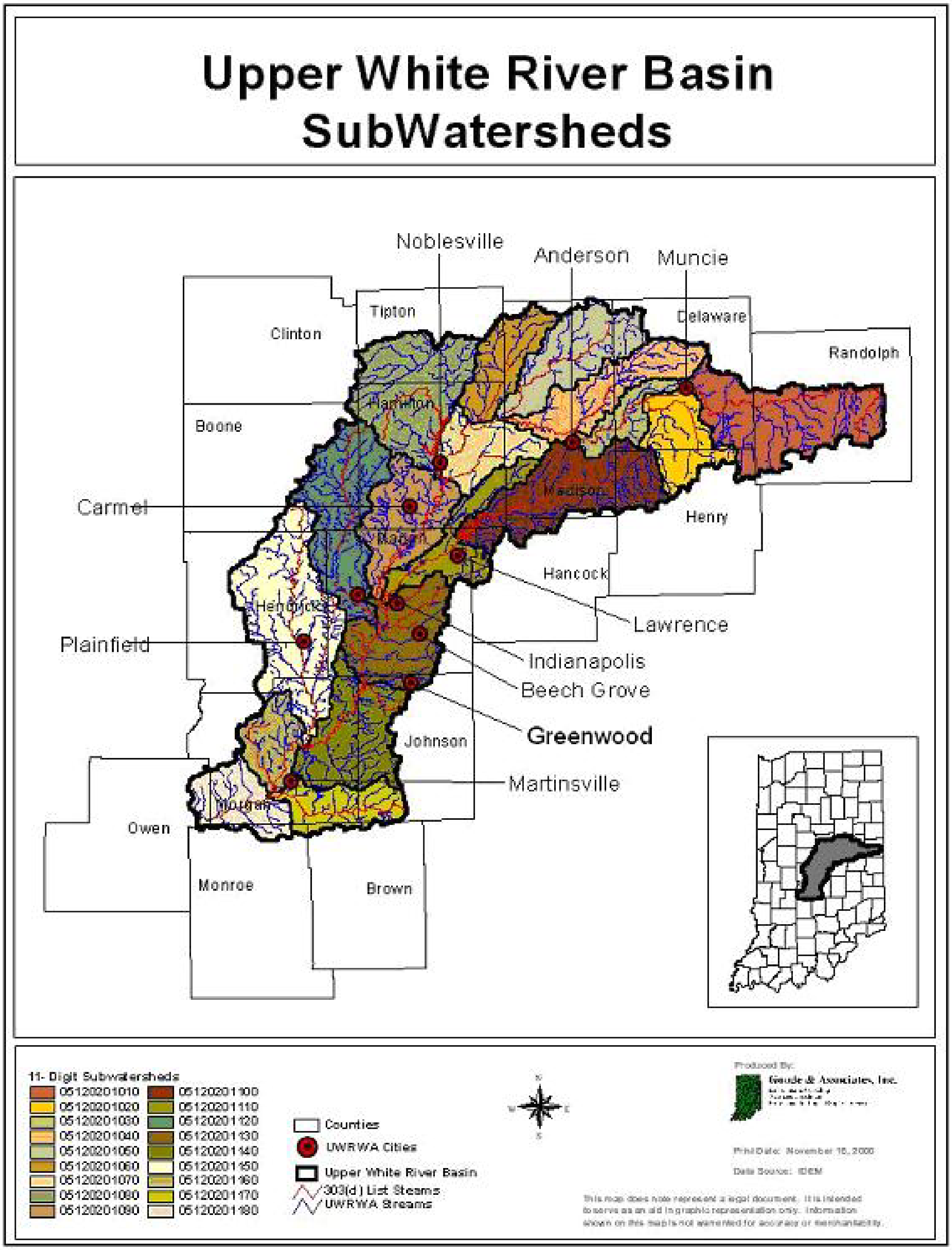

Figure 2-1
Upper White River Basin

tion of 790 feet NGVD. These reservoirs are used to attenuate high streamflows and augment low streamflows (Renn, 1998).

2.2.1 Historic Water Quality Conditions

Although the city faces many challenges to improve water quality, conditions are much improved from early in the 20th century. From 1900 through the mid 1970s, published reports document extremely poor water quality conditions in the White River due to inadequate wastewater treatment, industrial pollution and sewage overflows. According to the U.S. Geological Survey (USGS), researchers have reported 158 species of fish in the White River basin since 1875. Of these species, six have not been reported since 1900 and 10 have not been reported since 1943. Five of the 10 species not found since 1943 are darters, which are sensitive to changes in water quality. Since the 1820s, fish populations have declined due to alteration of stream habitat, overfishing, the introduction of nonnative species, agriculture, and urbanization. A historical record of fish species in the White River Basin is provided in the USGS *Water Resources Investigations Report 96-4232.*

In the early 1900s, 70 percent of the 33 principal cities and towns in the White River basin had no sewage treatment of any kind, and only 6 percent had some sort of sewage treatment plant (Tucker, 1922, p.307-308). Industries also commonly discharged untreated wastewater into streams. Tucker reported that untreated sewage from Indianapolis seriously degraded water quality for 100 river-miles downstream.

Since the turn of the last century, there have been many studies performed to determine the water quality of the White River and its tributaries. As early as 1906, R. L. Sackett, Professor of Sanitary Engineering at Purdue University and Sanitary Engineer to the State Board of Health, reported on the pollution in the White River from Winchester to Martinsville. In addition to pointing out the poor conditions of the White River, the report showed just how much the pollution in the river was annually costing the people along the stream reach. Sackett based this cost on the annual charges for water treatment in the cities of Muncie, Anderson, and Indianapolis, along with the annual cost attributed to typhoid, depreciation of farmlands, and loss of recreation.

In 1911, "An Investigation into the Sanitary Condition of White River with Reference to the Influence of the Sewage of the City of Indianapolis on the Purity of the White River" was submitted as part of the Thirtieth Annual Report of the State Board of Health of Indiana. H.E. Bernard, Ph.D., State Board of Health Chemist, and W.F. King, M.D., Assistant Health Commissioner authored the report. The report was commissioned as a result of complaints brought before the State Board of Health by Johnson and Morgan Counties concerning the effects of pollution from Indianapolis. The summary of the report states that the "White River, a stream which above Indianapolis has the characteristics of the flowing waters of Indiana, receives the industrial waste and domestic sewage of that city and thereby becomes an open sewer, flowing a liquid possessing all the attributes of sewage. The condition of the water improves but slightly during the first twenty miles of flow and as far south as Waverly."

In 1913, H.E. Bernard, Ph.D., Director, J.A. Craven, C.E., Sanitary Engineer, J.C. Diggs, A.B., Chemist and Bacteriologist, as part of the Thirty-second Annual Report of the State Board of Health of Indiana, published "A Sanitary Survey of White River." At the time, it was believed that natural purification and removal of pollutants occurred as the stream flowed from its source to its mouth. The authors concluded, "One noticeable fact, as shown in the analytical data, is the great purification that takes place in the river water. Above Winchester the water is of as good a quality as average surface water…the addition of sewage and manufacturing wastes at Muncie, Anderson, Noblesville and Indianapolis increases the pollution until below Indianapolis the worst condition in the river is found. The chemical reactions that take place are not complete until the water reaches Martinsville. Below this point the purification is rapid and the water at the mouth is practically the same in quality as above Winchester."

In 1922, W.M. Tucker wrote an article titled "Hydrology of Indiana," which read, "In 1909, Mr. J.A. Smith and the writer descended White River from Indianapolis and found the condition such that it produced extreme nausea. Night camp was pitched twenty river-miles by river below Indianapolis, and one-fourth of a river-mile from the river on a tributary stream, but the effects of sewage were still very disagreeable. The decaying carcasses of several hogs which had been thrown into the river by the packing houses of Indianapolis greatly aggravated the situation. The sewage of Indianapolis at this time formed practically half the volume of the stream. The bed of the stream was covered with a coating of dark, greasy, sludge, largely organic matter, to a depth of one inch or more." (W.M. Tucker, 1922, p. 302).

Later investigations in 1938 and 1942 continued to find poor water quality, high bacteria counts, low dissolved oxygen, and a sludge-covered riverbed in the White River. In 1938, S.C. Denham wrote "A Limnological Investigation of the West Fork and Common Branch of White River" In his report, Denham noted black sludge deposits were common for a few miles downstream from the Indianapolis sewage treatment plant. In addition, the polluted area was characterized by a great abundance of tolerant organisms. Minimum dissolved oxygen concentrations during July 1933 were 0.0 mg/L for 14 miles downstream from the treatment plant effluent discharge point, with the maximum dissolved oxygen concentrations reported as 0.0 mg/L from 2.5 to 6.5 miles downstream from the discharge.

A subsequent study in 1942 by E.L. Brinley entitled "The Effect of Pollution Upon the Plankton Population of the White River, Indiana" was published in the Indiana Department of Conservation, Investigations of Indiana Lakes and Streams. In this study, Brinley evaluated the White River during low flow in August and September of 1940 and determined that the phytoplankton community was almost totally destroyed by sewage from Muncie. The 5-Day Biological Oxygen Demand (BOD) and coliform bacteria concentrations downstream from Muncie were as high as 57.6 mg/L and 460,000 organisms/ml (46,000,000 colonies/100ml) respectively. Concentrations of dissolved oxygen downstream from Muncie were 0.0 mg/L for at least 1 mile during the same period and similar conditions were observed south of Indianapolis.

In the 1960s, John Winters, a biologist for the State of Indiana, and his colleagues stretched a net across the White River downstream of Indianapolis and injected poison into the water with the intent to survey the resulting number of dead fish. However, they discovered there were no fish to kill with the poison since the pollution in the White River had previously destroyed all fish. Sources of pollution were attributed to sewage, paper mill sludge, and packing house waste (Indianapolis Star, October 22, 2002).

Since the mid to late 1970s, water quality in the White River basin has begun to improve due to substantial public and private investment in improved municipal and industrial wastewater treatment, and reduced nonpoint-source contamination, such as soil erosion and agricultural runoff.

W.J. Shampine assessed the water quality of the upper White River in his 1975 report "A River-Quality Assessment of the Upper White River in Indiana," U.S. Geological Survey, Water-Resources Investigations and concluded that the river was most severely affected in the Indianapolis area. The median coliform bacteria count below Indianapolis was 360,000 colonies per 100 mL for bacteria analysis conducted in October of 1972. Shampine found that areas with historic problems of bacterial pollution continued to have problems in 1972 and that, "Generally speaking, the outlook for future quality of the White River and its tributaries is optimistic. Although increasing population and urbanization will stress the river, a burgeoning awareness of environmental problems by the populace and improvements in technology should, at least, help prevent wanton pollution."

2.2.2 Urbanization

The population in the White River basin has grown from 39,400 in 1820 (fewer than 200 in Indianapolis), to 860,000 in 1900 and to 2.37 million in 2000. Between 1940 and 1990, the most significant change in population density within the basin occurred in Marion County (Schnoebelen and others, 1999).

Approximately 85 percent of the 30 river-mile reach of the West Fork White River that flows through Marion County is urbanized. The remaining 15 percent of the river is located downstream of the Belmont Advanced Wastewater Treatment (AWT) plant and is bordered by either gravel mine, farm field, parkland, or residential development. Natural flows of the river are affected by regulation of reservoirs and by water withdrawals for municipal drinking water supply by Indianapolis Water. Urbanization profoundly alters the runoff and sediment supply to a stream. Urban streams tend to have higher peak flows and lower base flows than non-urban streams. As a result of this altered hydrologic setting, the stream will carve into and widen the streambanks where possible to accommodate the higher peak flows. When the storm runoff recedes, the reduced base flow is unable to sustain the enlarged channel. This results in urban streams that during dry weather frequently lack enough flow to fill the channel. These physical changes in stream morphology will be accompanied by equally profound reductions in stream water quality.

A 1998 USGS study concluded that urban areas were responsible for stream water quality degradation in Indianapolis (Fenelon, pp. 16-17). Two concerns were noted for urban areas: 1) elevated levels of trace metals and organic compounds found in streambed sediments (although generally not at sufficiently high levels to present a concern for human health); and 2) wet-weather impacts from runoff and sewer overflows, which can deplete oxygen and contribute to fish kills. Poor fish communities have been found in good habitats in some streams.

2.2.3 Agricultural Impacts

Agriculture is the major land use found within the White River basin. As a result, streams within the basin are affected by the chemicals used to control both insects and weeds that prove harmful to agriculture. Pesticides are commonly detected in the White River basin, with higher concentrations found in the streams following the first one or two spring applications. Atrazine, metolachlor, cyanazine, and alchlor are commonly detected. In addition, insecticides such as diazinon, chlorpyrifos, and fonofos are also commonly detected. Land-applied insecticides can have a significant impact on the types of pollutants found in waterways. Diazinon is commonly applied during midsummer on lawns, whereas chlorpyrifos and fonofos are more commonly associated with agriculture. At times, individual sample concentrations of pesticides have exceeded the EPA standards for drinking water or protection of aquatic life (Nowell and Resek, 1994). Most herbicides are introduced into the basin during the prime growing period between May and July. As with the insecticides, the herbicide concentrations are dependent on the amount of runoff and the time lapse between application and the rainfall events. Herbicides such as atrazine degrade or become bound in soil and plant material after two months, making them unavailable for transport by stormwater runoff (Fenelon, 1998). Significant rainfall occurring two months after the peak growing period usually contributes minor amounts of atrazine to the waterways. For about six weeks each year following spring herbicide applications, concentrations of atrazine near the mouth of the White River at its confluence with the Wabash exceed the U.S. EPA's maximum contaminant levels (MCL) for drinking water. The average atrazine concentration in the White River from 1992-1995 never exceeded the MCL (Fenelon, 1998).

The high levels of insecticides and herbicides identified in the White River, along with high bacteria levels in the White River upstream of Indianapolis, indicate that water quality in the White River is a regional problem with many pollution sources contributing to water quality impairments.

2.2.4 Hydrology and Physical Characteristics of Marion County Streams

The following descriptions of physical characteristics of Marion County streams are primarily derived from data provided by the U. S. Geological Survey, the City of Indianapolis Office of Environmental Services, and the Marion County Health Department. Information from these sources was supplemented by a detailed field survey conducted by the City of Indianapolis during May and June 2001. During this time, survey teams walked each water body and viewed aerial videos to determine the physical characteristics that would encourage or discourage water use. Teams noted areas of easy access to the water as well as dense vegetation, steep slopes, or infrastructure that would discourage water contact. The teams also took photographs and made spot observations of stream substrate and depth at CSO outfalls. These data are found in **Figures 2-2** through **2-15**.

The physical stream characteristic data were collected by the city in preparation for submitting a Use Attainability Analysis to IDEM. Streamflow, depth, substrate and accessibility information were used by the city to note possible opportunities and obstacles for recreational use in the waterways. The city used these data to help prioritize areas of concern as it moved forward with a number of early action projects to reduce or eliminate combined sewer overflows. These early action projects are described in Sections 4 and 7. It is important to note that these data are a snapshot of stream physical conditions at one point in time. While the data provide a good general view of stream conditions during the survey period, streams are dynamic and physical conditions can change rapidly. Details of the physical surveys are summarized in the following sections.

2.2.4.1 White River

Streamflow in the White River and its tributaries is highly variable and is related to precipitation. Flow in the White River is generally highest in the late winter and early spring and, occasionally, during the summer during intense rainfall. Both high and low streamflows can significantly affect the quality of the river water.

Streamflow: The U.S. Geological Survey maintains a gauging station on the White River at the Morris Street Bridge at river-mile 230.3 (2.6 river-miles downstream from Fall Creek, 3.4 river-miles upstream from Eagle Creek and 4.0 river-miles upstream from Indianapolis Power and Light dam). The drainage area above this gauging station is 1,635 square miles. Based on low flow measurements taken from 1943 - 1993, the lowest 7-consecutive-day flow over a 10-year period (i.e., Q_{7-10}) is 69 cubic feet per second (cfs) or 45 million gallons per day (mgd). According to the USGS the Q_{7-10}, which is used as a criterion in managing the quality of stream water, is exceeded 99.5 percent of the time at the USGS gauges located in Nora and at the Stout Generating Station. These two gauges measure White River flows upstream (Nora) and downstream (Stout) of the Belmont AWT plant.

Figure 2-2
White River at Lake Indy

Physical Description and Access: Appendix A1 illustrates data collected during the physical stream characteristic survey conducted in May and June 2001. The data indicate that the physical nature of White River changes as it flows through Marion County and that the river can be described in terms of four general sections, or reaches.

1. White River from Holliday Park to approximately 42nd Street (Appendices A1a and A1b) Land use in this area tends to be primarily low density residential. The river in this section is rather narrow (approximately 50 feet) and shallow with well-developed pool and riffle sequences and a rocky substrate. Much of the channel in this section is tree lined. Stream accessibility is mixed in this reach. While accessibility is good in public areas such as Broad Ripple, Marott, and Holliday Parks, much of this reach flows through low-density residential areas where access is restricted to individual landowners and their neighbors. There is a public boat launch in Broad Ripple Park.

Figure 2-3
White River Upstream of Raymond Street Bridge

2. 42nd Street to 16th Street (Appendices A1c and A1d) The Emrichsville (16th Street) dam determines much of the physical character of the river in this reach. The river is wider (approximately 80 feet), and deeper. Substrate becomes sandy as the river's velocity slows in response to the dam. Land use in this section is mixed, with much of the river bordered by city parks and golf courses. The central portion of this section, upstream of the dam, is locally known as Lake Indy, illustrated in **Figure 2-2**. This portion of the river is accessible as it flows through city parks and golf courses. There is a public boat launch in Riverside Park.

3. Emrichsville Dam to Morris Street (Appendices A1d and A1e) Downstream from the Emrichsville Dam at 16th Street, the river is bordered by levees as it flows through downtown Indianapolis. In this reach the river is approximately 80 feet wide and averaged 2-3 feet in depth during the June 2001 survey. Substrate is primarily fine sand and silt. This is the most urban portion of the White River in Indianapolis. Land use is this section is high density residential, mixed industry, and mixed urban. The floodplain in this section is restricted by the levees; much of the floodplain is maintained as turfgrass, with few trees along the channel. The photograph in **Figure 2-3** shows a portion of the river in this stream reach, just upstream of the Raymond Street bridge. White River State Park also is located along this stream reach. Accessibility is mixed in this reach. While the levees are steep, there are frequent unofficial access points that allow vehicles down on to the floodplain, as shown in the figure. Along the east bank of the river in the lower portions of this reach access is restricted by industrial development.

4. Morris Street to County Line (Appendices A1e through A1h) From Morris Street south to County Line Road, the White River begins to lose its urban character. The river begins to meander after it leaves the leveed downtown reach and pool and riffle sequences begin to develop. Land use in this section is predominately aggregate mining and agriculture with some light residential. The river in this section narrows to 50-60 feet and had an average depth of 2-3 feet during the June 2001 field survey. Access to the river in this section is limited by the aggregate mining and industry in the area.

2.2.4.2 Fall Creek

Fall Creek begins as a rural stream that flows through Henry, Madison and Hamilton counties. In Hamilton County, Fall

Creek discharges to, and is controlled by, Geist Reservoir. On the downstream side of the reservoir Fall Creek continues to flow as an urban stream as it continues through Marion County prior to its confluence with the White River. Of the 18 river-mile reach of Fall Creek that flows through Marion County, approximately 75 percent of the stream is urbanized. The remaining 25 percent of the creek is located along the former Fort Benjamin Harrison (i.e., Fort Harrison State Park). Downstream of the reservoir, natural flows of the river are affected by regulation of Geist Reservoir and by water withdrawals for municipal drinking water supply by Indianapolis Water near Keystone Avenue.

Streamflow: Like the White River, streamflow in Fall Creek is highly variable and is related to precipitation. Flow in Fall Creek is generally highest in the late winter and early spring and, occasionally, during the summer during intense rainfall. Both high and low streamflows can significantly affect the quality of the river water. During wet weather, Fall Creek streamflows are predominantly made up of CSO flows downstream of the Keystone Dam. During the summer and fall, most of the water above the Keystone Dam is diverted into the Indianapolis Water treatment plant, allowing little or no water to pass over the dam.

The U.S. Geological Survey maintains a gauging station on Fall Creek at Millersville (i.e., 9.2 river-miles upstream of its mouth). The drainage area above this gauging station is 298 square miles. Based on low flow measurements taken from 1943-1993, the $Q_{7\text{-}10}$ is 37 cfs or 24 mgd.

Physical Description and Access: Appendix A2 illustrates data collected during the physical stream characteristic survey conducted in May and June 2001. These data suggest that Fall Creek in the combined sewer area of Indianapolis can be divided into three sections with different physical characteristics.

Figure 2-4
Fall Creek Downstream of Illinois Street Bridge

1. Keystone Dam to 34th Street (Appendices A2a and A2b) At the Keystone Dam, Indianapolis Water removes approximately half of the average annual flows in Fall Creek to help supply drinking water for the City of Indianapolis. Fall Creek divides into multiple channels in the upstream portion of this section as the stream adjusts to the water removal. Numerous sediment wedges and sandbars have formed in this area due to the reduced flow being unable to transport the sediment load. Stream depth varies in this section from 1-3 feet in the pools to exposed sandbars in mid channel. Some of these sandbars have been colonized by vegetation and several small islands have formed. The channel substrate is primarily sand. Fall Creek varies in width in this section from 50 to 60 feet. Heavy vegetation borders the channel throughout much of this section. Land use in the area is primarily residential with some pockets of light industry. Heavy vegetation and steep slopes along much of the stream limit access in this reach.

2. 34th Street to Boulevard Dam (Appendices A2c through A2e) From 34th Street to Boulevard Dam, Fall Creek flows through older residential neighborhoods. Levees built to protect the area from flooding frequently border the channel and restrict channel movement. There is significant in-channel sediment buildup in this section of Fall Creek as the stream continues to adjust to water withdrawals at the Keystone Dam. **Figure 2-4** shows an example of sediment buildup downstream of the Illinois Street bridge. The channel substrate is primarily sand. Stream depth continues to vary in this section and ranged from 1-3 feet in the pools to exposed sandbars in mid channel during the field survey. Fall Creek varies in width in this section from 50 to 60 feet to approximately 80 feet above Boulevard Dam. Large trees typically border the channel in this area. Steep flood control levees restrict access throughout much of this reach. There are, however, a number of potential access points along the Fall Creek Greenway.

3. Boulevard Dam to White River Confluence (Appendices A2e through A2g) Fall Creek has been straightened or channelized throughout most of this lower reach. **Figure 2-5** shows the channelization upstream of 16th Street. This type of stream modification was commonly done in the past in an effort to reduce flooding and make a stream more efficient at moving water through an area. Channelizing is rarely done anymore, as most data suggest that negative impacts to the stream outweigh benefits. Streams frequently adjust to channelization by incising or downcutting, which can lead to unstable banks. As a result of past channelization,

Figure 2-5
Fall Creek Upstream from 16th Street

Fall Creek has fairly high and unstable banks throughout much of this section. In this channelized section of Fall Creek the channel narrows to an average of 50 or 60 feet and deepens to 2-3 feet. The channel substrate is primarily sand. Stream side, or riparian, vegetation in this reach tends to be dominated by invasive bush honeysuckle (*Lonicera spp.*) that further contributes to erosion in this area. The city's Parks Department is working to control the spread of these plants. Land use in this area is mixed parkland, residential, and light industry. Stream access is mixed in this reach. The stream is accessible in Watkins Park and Fall Creek & 16th Street Park and along much of the Fall Creek Greenway. However, steep levee slopes, heavy vegetation, and unstable banks tend to make that access difficult.

2.2.4.3 Eagle Creek

Eagle Creek begins as a rural stream that flows through Hamilton, Boone and Marion counties. In Marion County Eagle Creek discharges to, and is controlled by, Eagle Creek Reservoir. On the downstream side of the reservoir, Eagle Creek continues to flow as an urban stream as it continues through Marion County prior to its confluence with the White River. Of the 22-mile reach of Eagle Creek that flows through Marion County, approximately 70 percent of the stream is urbanized. The remaining 30 percent of the creek is located along parkland (i.e., Eagle Creek Park) upstream of the reservoir. Natural flows of the river are affected by regulation of Eagle Creek Reservoir and by water withdrawals for municipal drinking water supply by Indianapolis Water and the Speedway Water Utility.

Streamflow: Streamflow in Eagle Creek is regulated by Indianapolis. Approximately 3.1 cfs or 5.6 mgd are released from the reservoir to provide water supply for the Town of Speedway and meet minimum daily flow requirements for Eagle Creek.

Flow in Eagle Creek is generally highest in the late winter and early spring and, occasionally, during the summer during intense rainfall. Both high and low streamflows can significantly affect the quality of the river water.

The U.S. Geological Survey maintains a gauging station on Eagle Creek at Lynhurst Drive (i.e., 7.1 river-miles upstream of its mouth). The drainage area above this gauging station is 174 square miles. Based on low flow measurements taken from 1943-1993, the $Q_{7\text{-}10}$ is 3.3 cfs or 2.1 mgd.

Physical Description and Access: Appendix A3 illustrates data collected during the physical stream characteristic survey conducted in May and June 2001. These data suggest that Eagle Creek in the combined sewer area of Indianapolis can be divided into three sections with different physical characteristics.

1. Little Eagle Creek above Cossell Road (Appendix A3a) This is a short (approximately 0.75 mile) section of Little Eagle Creek. This reach is characterized by dense vegetation along both sides of the channel, as shown in **Figure 2-6**, a photograph of Little Eagle Creek at Michigan Street. The channel in this section is wide (20-25 feet) and the flow in the channels tends to be shallow (approximately 1 foot during the May/June 2001 field survey). The channel substrate is rocky. Land use in this section is primarily industrial with some small residential areas. As this figure illustrates, stream access in this reach is limited by dense vegetation.

Figure 2-6
Little Eagle Creek at Michigan Street

Figure 2-7
Eagle Creek Upstream of Minnesota Street and Pershing Avenue

2. Little Eagle Creek and Eagle Creek from Cossell Road to Kentucky Avenue (Appendices A3a through A3d) In this section both Little Eagle Creek and Eagle Creek are bounded by earthen levees, as shown in **Figure 2-7**, a photograph of Eagle Creek upstream of Minnesota Street and Pershing Avenue. The channel is wide (from 20 to 30 feet) and flows are shallow (less than 1 foot deep during the May/June 2001 field survey). The channel substrate is sandy. Land use is mixed industry and high density residential. The levees are maintained in mown turf. Some riparian forest is developing near the channel in the lower reaches of this section. Despite the steep levees throughout much of this reach, accessibility is good. There are several areas where vehicles can drive right up to the stream, or as shown in **Figure 2-7**, right into the stream.

3. Eagle Creek from Kentucky Avenue to White River (Appendices A3e and A3f) This is a channelized reach of Eagle Creek that flows through a heavily industrial area. The channel is bounded by earthen levees throughout this section. The levees are maintained in mown turf. Some riparian forest is developing near the channel in the lower reaches of this section. The channel is wide (from 20 to 30 feet) and flows are shallow (less than 1 foot deep during the May/June 2001 field survey). The channel substrate is sandy. Accessibility is very limited in this reach by industrial activity along both banks.

2.2.4.4 Pleasant Run

Pleasant Run is an urban stream located entirely within Marion County. The stream is approximately 10 river-miles long and flows into the White River at a point just east of the Belmont AWT plant. Approximately 50 percent of the stream flows through city parkland. The remainder flows through urban and industrial areas.

Streamflow: Like the White River, streamflow in Pleasant Run is highly variable and is related to precipitation. Flow in Pleasant Run is generally highest in the late winter and early spring and, occasionally, during the summer during intense rainfall. Both high and low streamflows can significantly affect the quality of the river water. During wet weather, Pleasant Run is dominated by flows from CSOs.

The U.S. Geological Survey maintains a gauging station on Pleasant Run at Arlington Avenue (i.e., 7.9 river-miles upstream of its mouth). The drainage area above this gauging station is 7.58 square miles. Based on low flow measurements taken from 1943-1993, the $Q_{7\text{-}10}$ is 0.1 cfs or 0.06 mgd.

Physical Description and Access: Appendix A4 illustrates data collected during the physical stream characteristic survey conducted in May and June 2001. These data suggest that Pleasant Run in the combined sewer area of Indianapolis can be divided into two sections with different physical characteristics.

1. Pleasant Run Golf Course (10th Street) to Bluff Road (Appendices A4a through A4h) This section includes most of Pleasant Run in the combined sewer area. From 10th Street to Bluff Road, Pleasant Run flows through a golf course (Pleasant Run Golf Course), three city parks (Ellenberger, Christian, and Garfield) and the wide Pleasant Run Greenway. Throughout much of this section Pleasant Run is a classic small urban stream. Baseflow is minimal as a result of a heavily urbanized watershed, which results in very low flow conditions during dry months and high flows in response to runoff. This tremendous variation in flow has created a channel that is very wide relative to its average discharge. In this reach the channel is approximately 20 feet wide; average flows during the May/June 2001 field survey ranged from 6 inches to 1 foot deep. **Figure 2-8**, a photograph of Pleasant Run at Ellenberger Park, shows how high runoff conditions have created a rocky substrate as most of the finer grained sediments are removed by the high flows. Floodplain vegetation varies from fairly high quality native riparian (streamside) forest communities to large stands of invasive bush honeysuckle (*Lonicera spp*.). Parks and greenways dominate land use. The adjacent neighborhoods are primarily low density residential.

In this section of Pleasant Run there is one large area of industrial land use. From English Avenue to Prospect Street, Pleasant Run flows through the Citizen's Gas and Coke Util-

Figure 2-8
Pleasant Run at Ellenberger Park

ity property. This section of Pleasant Run is markedly different from the surrounding area. Throughout the Citizen's Gas facility there is light vegetation along the stream and steep, unstable banks.

Throughout most of this reach, dense vegetation and steep slopes limit accessibility in some locations. However, there are public access points in the parks and along the greenway. Pleasant Run is not accessible to the public as it flows through the Citizen's Gas complex.

1. Bluff Road to White River (Appendix A4h) This is a short (approximately 0.5 mile) downstream section of Pleasant Run that has been channelized, as shown in the photograph in **Figure 2-9**. This reach runs through the Bluff Road industrial corridor. Streamside vegetation is primarily invasive bush honeysuckle (*Lonicera spp*.) with some areas of mown turfgrass. Stream banks in this reach are steep and unstable; erosional slumps are common. The stream channel in this section of Pleasant Run is 15-20 feet wide. During the May/June 2001 field survey flow averaged 6 inches deep. This reach of Pleasant Run is fairly accessible. Dense vegetation can limit access at some points, but that vegetation is not continuous. There is some limited accessibility near the Bluff Road industrial corridor.

Figure 2-9
Pleasant Run at Bluff Road

2.2.4.5 Pogues Run

Pogues Run is an urban stream located entirely within Marion County. The stream is approximately 11 river-miles long and flows into the White River at a point just north of the Interstate 70 bridge over White River, near downtown Indianapolis. The Pogues Run watershed drains an area of about 13.0 square miles. This drainage area includes a major portion of downtown Indianapolis and areas east and northeast of downtown.

Streamflow: The lower portion of Pogues Run is enclosed in an underground conduit. The majority of the conduit, built in 1914-1915, consists of two nearly rectangular sections, each with a maximum height of 8 feet and a width that varies from 16 to 19 feet. The conduit extends under downtown Indianapolis, from New York Street to the White River, for a distance of approximately 2.2 river-miles. The last 310-foot portion of the conduit, built in 1936, consists of three 9-foot-high by 12-foot-wide culverts.

The U. S. Geological Survey does not maintain a gauging station on Pogues Run and does not publish a 7-day, 10-year low flow for the stream. However, given the similarities between the Pogues Run and Pleasant Run watersheds, a low flow similar to the Q_{7-10} for Pleasant Run can be assumed. That would make Q_{7-10} for Pogues Run ~ 0.1cfs.

Physical Description and Access: Appendix A5 illustrates data collected during the physical stream characteristic survey conducted in May and June 2001. These data suggest that Pogues Run in the combined sewer area of Indianapolis can be divided into two sections with different physical characteristics.

1. 21st Street (Forest Manor Park) to State Avenue (Spades Park) (Appendices A5a and A5b) This section of Pogues Run flows through three city parks: Forest Manor, Brookside, and Spades. Vegetation along the stream is heavy and is dominated by invasive bush honeysuckle (*Lonicera spp*.), which the city's Parks Department is working to control. This type of streamside vegetation actually promotes erosion and contributes to bank instability. In many ways, Pogues Run is a classic small urban stream. Baseflow is minimal as a result of a heavily urbanized watershed, which

Figure 2-10
Pogues Run Near Temple Avenue
Upstream of CSO 099

results in very low flow conditions during dry months and high flows in response to runoff. **Figure 2-10**, showing Pogues Run near Temple Avenue, illustrates how the tremendous variation in flow has created a channel that is very wide relative to its average annual discharge. In this section the channel is 10 to 15 feet wide. Flow during the field survey was less than 1 foot deep. High runoff has created a very rocky substrate in much of this reach by removing most of the finer grained sediments. As illustrated in **Figure 2-10**, dense vegetation and steep slopes can limit stream access throughout most of this reach. However, there are abundant public access points in the parks and along the greenway.

2. State Avenue (Spades Park) to New York Street (Appendices A5b and A5c) From State Avenue to New York Street, Pogues Run flows through a mixed residential and urban corridor. Pogues Run in this section has been channelized, or straightened, and several sections have been armored with concrete slabs or riprap. As a result of the channelization the channel narrows, and typically ranges from 5 to 8 feet wide throughout this section. During the 2001 field survey, flow averaged less than 1 foot deep. **Figure 2-11**, a photograph of Pogues Run downstream of Arsenal and 10th Street bridge at School 101, illustrates how the substrate remains rocky as a result of high runoff flows, but bank instability leads to a buildup of finer grained sediment during low-flow periods. Streamside vegetation is typically turfgrass. This section of Pogues Run is generally very accessible.

2.2.4.6 Lick Creek

Streamflow: Lick Creek is an urban stream located entirely in Marion County. Lick Creek begins in east central Marion County and flows generally southwest to a confluence with the West Fork of the White River on the south side of Marion County. The main channel is approximately 16.6 miles long and has a drainage area of approximately 26.2 square miles. The U.S. Geological Survey maintains a gauging station on Lick Creek at Sherman Drive (approximately river mile 6.2). Average annual discharge for Lick Creek at Sherman Drive for the period of record (1970 –2002) was 20 cfs or approximately 13 mgd. The Q_{7-10} for Lick Creek is 0.2 cfs at Sherman Drive. Land use in the Lick Creek watershed is primarily residential.

Physical Description and Access: Appendix A6 provides a graphical representation of data collected during the physical stream characteristic survey conducted in May and June 2001. These data suggest that Lick Creek in the combined sewer area of Indianapolis can be divided into two sections with different physical characteristics.

1. Madison Avenue to Meridian Street (Appendices A6a and A6b) For most of this reach, Lick Creek flows through an armored channel, illustrated in **Figure 2-12** by a photograph taken near CSO 235. Stream width for most of the reach ranges from 10 to 15 feet. During the May/June 2001 field survey depth of flow was 6 inches. Channel substrate in most of this reach is concrete. Land use is industrial. No natural floodplain exists in this reach. Some areas of the armored channel have been colonized by vegetation. Accessibility is mixed in this section of Lick Creek. In the uppermost reach of this section, Lick Creek is accessible only

Figure 2-11
Pogues Run Downstream of Arsenal and
10th Street Bridge and School 101

Figure 2-12
Lick Creek Downstream of CSO 235

Figure 2-13
Lick Creek Near Bluff Road

from the south bank; the north side of the stream is bounded by I-465. Immediately downstream from this reach, Lick Creek flows in between the eastbound and westbound lanes of I-465 and is inaccessible.

2. Meridian Street to the White River (Appendices A6b through A6d) In this lower reach Lick Creek reverts to a more natural channel, although this reach has been channelized in some areas, as shown in **Figure 2-13**, a photograph taken near Bluff Road. Stream width for most of the reach ranges from 10 to 15 feet. During the May/June 2001 field survey depth of flow was 6 inches. Channel substrate is rocky. Some sections of the floodplain are heavily vegetated while others are in mown turf. Land use is primarily industrial with some light residential areas. Lick Creek is fairly accessible throughout this reach. Industrial areas, dense vegetation and steep banks can locally limit access, but these areas are not continuous and numerous potential access points exist.

2.2.4.7 State Ditch

Streamflow: State Ditch is an urban stream located entirely in Marion County. State Ditch begins in south western Marion County and flows generally south to a confluence with the West Fork of the White River on the south side of Marion County. The main channel is approximately 8.5 miles long. The State Ditch watershed has a drainage area of approximately 10.7 square miles at its confluence with the West Fork of the White River. There are no gauging stations on State Ditch. The $Q_{7\text{-}10}$ for State Ditch has not been calculated, but given the observed low flow character of the stream, can be estimated as 0.0 cfs. Land use in the State Ditch watershed is primarily residential in the headwaters region above I-465 and agricultural in the lower reaches south of the interstate highway.

Physical Description and Access: Appendix A7 illustrates data collected during the physical stream characteristic survey conducted in May/June 2001. These data suggest that State Ditch in the combined sewer area of Indianapolis can be divided into three sections with different physical characteristics.

1. Airport Expressway to Kentucky Avenue (Appendix A7a) This section of State Ditch has been extensively channelized. It is also, much like Pogues Run and Pleasant Run, a classic small urban stream. Baseflow is minimal as a result of a heavily urbanized watershed, which results in very low flow conditions during dry months and high flows in response to runoff. This tremendous variation in flow has created a channel that is wide relative to its average annual discharge. In this reach the channel is approximately 5 feet wide. Flow depth during the May/June 2001 field survey ranged from 2 to 6 inches. As with most channelized streams, the stream banks are high and frequently unstable. The channel substrate is rocky in response to the high flows associated with runoff, as shown in **Figure 2-14**, a photograph taken downstream of CSO 217. Land use in this area is primarily residential. Stream side vegetation is frequently dense and is usually dominated by invasive bush honeysuckle (*Lonicera spp*.). In this headwaters reach of State Ditch, accessibility is limited in a number of areas by dense vegetation, as shown in **Figure 2-14**. This vegetation is not continuous and numerous potential access points exist.

2. Kentucky Avenue to I-465 (Appendices A7a through A7c) From Kentucky Avenue to I-465 most of the channel begins to meander and develop a more natural channel pattern. Some small areas are channelized. This reach is still heavily im-

Figure 2-14
State Ditch Downstream of CSO 217

pacted by urbanization. Stream banks are high and tend to be unstable. Stream side vegetation is frequently dense and is usually dominated by invasive bush honeysuckle (*Lonicera spp*.). In this reach the channel is approximately 5 feet wide. Flow depth during the May/June 2001 field survey ranged from 2 to 6 inches. **Figure 2-15** illustrates the low flow in State Ditch downstream of the Mooresville Street bridge. Land use is residential. Similar to the headwaters reach of State Ditch, accessibility is limited in some areas by dense vegetation. However, this vegetation is not continuous and numerous potential access points exist.

3. I-465 to the White River (Appendices A7c and A7d)
From I-465 to its confluence with the White River, State Ditch becomes a rural stream as the channel meanders through agricultural fields. Stream banks remain high and unstable. Floodplain vegetation, where present, is frequently restricted to a narrow bank immediately adjacent to the stream. In this reach the channel is approximately 5 feet wide. Flow depth during the May/June 2001 field survey ranged from 2 to 6 inches. This reach of State Ditch flows through privately owned farms, which restricts public access. Steep, unstable banks throughout much of the reach also discourage access.

2.2.5 Fisheries and Stream Biology

Biological assessments can identify water quality impairments and help evaluate the success of mitigation efforts. Biological criteria complement chemical and physical measures of water quality. DPW has developed a cooperative program with the USGS to use biological indicators to monitor and improve the interpretation of the overall health of the White River and its tributaries in Marion County. Their most recent study, *Biological Assessment of Streams in the Indianapolis Metropolitan Area, Indiana, 1999–2001*, was authored by David C. Voelker and published in 2004.

The aquatic ecology of the White River basin has been impacted by human activity since the early 1800s. Starting with early deforestation to clear the land for agriculture, aquatic organisms have been subjected to a number of impacts. The initial clearing of the land led to erosion of cropland, bank erosion from pasturing of farm animals near streams, and the resulting siltation of the stream bed. Overfishing also took a toll on the fishery. As early as 1883 Ryland Brown was writing that "the abundance of fish, for which the White River and it tributaries were once noted, has greatly diminished…" (Brown, 1883). By the early 1900s the streams in Marion County were also being subjected to the impacts of early industrialization as industrial waste and untreated sewage flowed into the streams. Early reports indicate that the White River was impacted for over 100 miles by the untreated sewage from Indianapolis (Craven, 1914).

The lack of early baseline studies makes it difficult to gauge just how much this combination of agricultural and industrial impacts altered aquatic life in Marion County streams. This much is known: historically 158 species of warm-water fish from 25 families have been reported in the White River basin. Since the early 1970s significant advances have been made in the treatment of industrial and municipal wastewater (Crawford and Wangsness, 1991). Prior to the City of Indianapolis making improvements in its wastewater treatment plants and implementing industrial pretreatment programs, researchers were reporting as few as nine species in the White River near Indianapolis. With the improvements in wastewater treatment since the 1980s, researchers in 1995 were reporting 63 species of fish in the White River at Indianapolis (USGS, 1996).

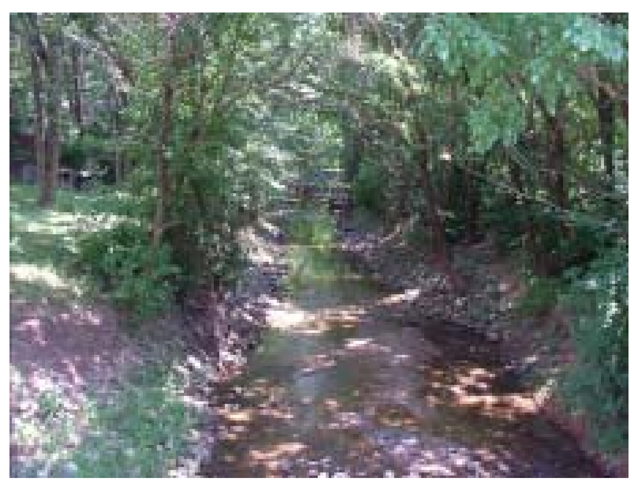

Figure 2-15
State Ditch Downstream of Mooresville Street

A cooperative DPW and USGS study conducted from 1999 to 2001 identified 52 fish species and one hybrid in the White River at Indianapolis. This number is significant. In December 1999, a discharge near the City of Anderson caused a massive fish kill in White River from Anderson to Indianapolis. Most species of fish were killed, including fairly hardy fish such as catfish and carp. In March and July of 2000 Department of Natural Resources (DNR) biologists conducted a survey of the impacted portion of the White River. The survey found that food sources for fish were plentiful and that wild fish had begun to move into the river from tributaries, backwaters, upstream and even from downstream. Fish were found to be reproducing in the affected area of the river. Biologists developed plans to stock sport fish before an abundance of predatory fish established territories. In spring of 2000, the DNR stocked the river with 1,937 adult game fish to spawn and 63,000 channel catfish fingerlings ranging in length from 3 to 4 inches. In cooperation with White River Rescue 2000, a not-for-profit organization, a coordinated restocking of the river occurred in October 2000 with more than 300,000 bass, bluegills, crappies, and catfish being released at 18 sites between Anderson and Indianapolis. Additional stocking was done in 2001 and 2002. As a result of the restoration efforts and the overall improvements in water quality in the White River, less than a year after the fish kill the number of species identified in the White River at Indianapolis was close to the high number recorded in 1995.

Benthic macroinvertebrates can provide a more conservative appraisal of current water quality. Because fish are more mobile, they can migrate out of the reach if conditions slowly worsen. Macroinvertebrates are less mobile and their presence or absence will often provide insight into current water conditions. As part of the cooperative agreement between DPW and USGS, the benthic invertebrate community is regularly sampled. Studies have been done from 1981-1987 (Crawford, Martin, and Wangsless, 1992), from 1994-1996 (Voelker and Renn, 2000), and from 1999-2001 (Voelker, 2004).

During the 1999-2001 study twelve sites were sampled, six on the White River and six on the tributaries. A total of 246 benthic invertebrate samples representing 82 data sets were collected during the study. In the samples collected, 151 taxa were identified. The data were used to determine general descriptions of the benthic invertebrate community and to calculate biological indices. Benthic invertebrate indices calculated include:

- The EPT index, which is a measure of the total number of distinct taxa in three pollution-sensitive insect orders: the Ephemeroptera (may-flies), Plecoptera (stoneflies), and Trichoptera (caddisflies.)
- The Hilsenhoff Biotic Index (HBI), calculated from the number of arthropods and their tolerance to pollution.
- The Invertebrate Community Index (ICI), which used community metrics to describe the benthic invertebrate community.

The indices were used to determine variations between sites and changes at sites throughout the study period. Benthic invertebrate conditions at sites tended to be relatively stable over time on the index scores calculated.

On the White River, EPT scores in Nora consistently scored the highest of all White River sites, and sites in the immediate vicinity of Indianapolis (Morris and Harding) had the lowest scores indicating the negative effect of conditions in the reach. There was some improvement in the EPT score in the farthest downstream reached, indicating that conditions were improving somewhat. For the tributary sites, EPT values were highest on Buck Creek and lowest at Pogues Run.

HBI scores ranged from 4.95 (good) to 9.59 (very poor) at the White River sites, and from 5.2 (good) to 7.96 at the tributary sites. Nora had the lowest scores, indicating fewer pollution tolerant species were present as the White River enters Marion County. The Morris and Harding sites typically had the highest HBI scores, representing the least favorable water quality conditions of all White River sites. On the tributaries, Buck, Eagle, and Fall Creeks had HBI scores indicating generally fair water-quality conditions, while Pleasant Run and Pogues Run rated the fairly poor to poor range.

The ICI was developed by the Ohio Environmental Protection Agency to provide descriptive statistics to compare sites within a study unit. On the White River, ICI scores indicated the best conditions were at the Nora site, and that conditions degraded in the downtown Indianapolis areas with slight improvement in the farthest downstream reached of the study area. At the tributary sites, Buck Creek (a non-CSO stream) was the only site to achieve exceptional water quality scores. Williams Creek (a non-CSO stream) also had generally good scores, while the remaining sites – all of which have CSOs located on them – reflected only fair conditions (Voelker, 2004).

DPW continues to work with USGS to monitor the biological health of Marion County waterways.

2.3 Water Quality Parameters of Concern

Water quality problems in Indianapolis have a number of causes, including CSOs, wet-weather bypasses at wastewater treatment plants, urban stormwater, failing septic systems, construction-related soil erosion, and upstream pollution sources. The current water quality parameters of concern in each receiving water are presented in **Table 2-1** and discussed further below. The parameters of concern include depressed dissolved oxygen levels, high bacteria levels, impaired biotic communities, fish consumption advisories, and elevated metals and organics in streambed sediments. CSO discharges contribute to high bacteria levels and depressed dissolved oxygen levels. The city developed computer models of the combined sewer system, White River, and Fall Creek, verifying the accuracy of these models and presenting their findings in the "Indianapolis CSO LTCP Hydraulic and Water Quality Modeling Report" (Department of Public Works - Indianapolis Clean Stream Team (DPW-ICST, 2004) and the SRCER (DPW-ICST, June 2003).

2.3.1 Bacteria

The water quality standard for bacteria has been established by the Indiana Water Pollution Control Board at 235 *E. coli* colonies/100 mL (instantaneous) and 125 *E. coli* colonies/100 mL (monthly geometric mean) to protect full-body contact recreation. IDEM has assessed more than 99 percent of Indiana's rivers and streams for their ability to support fish, shellfish, macroinvertebrates and other aquatic life. Water quality assessments began in 1997 and were completed for the entire state in 2002. Sixty-four percent of the streams were found to fully support aquatic life. Of the 8,660 stream miles surveyed for recreational use, about 59 percent were found to support swimming and boating. *E. coli* bacteria indicated unsafe recreational levels in over 3,500 stream miles (IDEM, 2004).

Even during dry weather, pollutant concentrations in White River often exceed bacteria standards at the Marion-Hamilton County border and downstream of the Indianapolis Power & Light (IPL) dam, located south of the Belmont AWT plant. During wet weather, when combined sewers and stormwater contribute bacteria, the standard is exceeded throughout the watershed. The peak concentrations are much higher in the CSO areas than the non-CSO areas, but both areas far exceed the bacteria water quality standard.

Table 2-1
Water Quality Problems in Indianapolis

Stream	Water Quality Condition of Concern
White River	1) Depressed dissolved oxygen (DO) levels
	2) High bacteria levels
	3) Impaired biotic communities
	4) Fish consumption advisories (PCB & mercury)
	5) Elevated metals concentrations in streambed sediments
	6) Elevated organic concentrations in streambed sediments
Fall Creek	1) Depressed dissolved oxygen (DO) levels
	2) High bacteria levels
	3) Impaired biotic communities
	4) Elevated organic concentrations in streambed sediments
Eagle Creek, Pleasant Run and Pogues Run	1) High bacteria levels
	2) Impaired biotic communities
	3) Elevated metals concentrations in streambed sediments
	4) Elevated organic concentrations in streambed sediments

This table is based on studies by the Office of Environmental Services, Indiana Department of Environmental Management, and the U.S. Geological Survey.

Extensive instream water quality data collected by the city, Marion County Health Department, and IDEM since the 1990s indicate that CSO-impacted streams in Marion County are unable to support the full-body contact recreational use. IDEM's 2002 and 2004 Clean Water Act § 303(d) lists of impaired waters in the State of Indiana identify White River, Fall Creek, Eagle Creek, Pleasant Run, Pogues Run, Bean Creek, and State Ditch as being impaired for *E. coli* bacteria. Even streams that are not affected by CSOs are listed as impaired for *E. coli*, including Dollar Hide Creek, Fishback Creek, and Mars Ditch.)

Nationally, virtually no *urban* streams consistently meet bacteria water quality standards (WQS) and support full-body contact recreation. A number of cities have collected in-stream bacteria data that demonstrate the severe disparity between bacteria levels in urban waterbodies and primary contact recreation standards. These cities include Atlanta, Boston, Cincinnati, Louisville, New York City and Pittsburgh. The cause of bacteria exceedances is not solely CSO discharges. As in Indianapolis, the streams outside the CSO area do not meet the bacteria standard due to stormwater discharges and the pollutants they carry from wildlife and domestic animals.

2.3.2 Dissolved Oxygen

The Indiana Water Pollution Control Board has established a water quality standard for dissolved oxygen (DO) to support aquatic life at no less than 4 mg/L for a single sample and 5 mg/L daily average. Within the combined sewer area, modest size storms can cause the DO concentration to drop below standard on both Fall Creek and the White River. From July through October, CSO discharges and stormwater runoff coupled with low river flow and high river temperature can contribute to low DO levels in both streams.

A 1995 Camp Dresser & McKee (CDM) study concluded that two fish kills on the White River in September 1994 were caused by extremely low DO levels. The study identified eight related factors that caused the events, with three factors (river hydraulics, wet-weather biochemical oxygen demand (BOD) loads, and low streamflow) determined to be the principal causes.

A 1995 USGS study monitored water quality in Fall Creek, which drains 35 percent of the Indianapolis CSO area. The study sought to compare baseflow water quality to storm runoff water quality, and water quality in urbanized areas to water quality in non-urbanized area. Three dissolved oxygen gauges were installed: one upstream of the CSO area at Emerson Avenue, one in the middle at Central Avenue, and one downstream at 16th Street. Of the three gauges, the least concentration of DO was found at Central Avenue. The measured DO concentration at this location ranged from 3.9 mg/L to 5.2 mg/L, which at times was below the Indiana minimum water quality standard of 4 mg/L. Although the 1995 dissolved oxygen samples would not be expected to produce a fish kill, the September 1994 fish kills and other historical fish kills had DO levels well below 3.9 mg/L. The low DO level was most likely caused by an increase in oxygen demand by CSOs, urban runoff, resuspension of deposited organic material, and warmer summer temperatures decreasing the solubility of dissolved oxygen. Black sludge deposits that can exert an oxygen demand also were found along the bottom of the stream within the CSO area. Section 2.4.1 presents more recent DO sampling for Fall Creek and White River.

2.3.3 Mercury and PCBs

Mercury is a naturally occurring metal that does not break down in the environment, but cycles between land, water and air. Some mercury that reaches the White River occurs naturally. Mercury also is released from coal-burning power plants, and from household and industrial wastes. Most of the mercury load on the White River is from airborne sources, which cannot be controlled through the NPDES process or CSO control.

According to IDEM's 2003 Fish Consumption Advisory (FCA), the state has issued FCAs for mercury and PCBs for the West Fork of White River within Marion County. Both mercury and PCBs collect in soil, water and sediment as well as in microscopic animals. As a result, these contaminants tend to build up or bio-accumulate in fish within these waters. The 2003 Fish Consumption Advisory did not carry an advisory for Fall Creek in Marion County, although it did carry an advisory upstream in Madison and Hamilton counties. The City of Indianapolis is currently monitoring mercury loads as required in its NPDES permits. The permits required the city to submit a Mercury Sampling and Analysis Plan (MSAP) to IDEM in 2002. A revised plan was resubmitted to the agency in August 2004. The approach considers potential mercury sources (i.e. dental offices, laboratories, hospitals, etc.) not as individual sources but as groups or clusters. A review of potential non-industrial sources identified that most sources tended to be geographically located in groups. The revised mercury sampling program was approved by IDEM on Nov. 16, 2004. The city plans to complete the sampling program in 2005.

The mercury question has been further complicated by a change in the mercury standard. NPDES permits IN0023183 (Belmont Advanced Wastewater Treatment Plant) and IN0031950 (Southport Advanced Wastewater Treatment

Plant) contain more stringent limitations for mercury in treatment plant effluent. Because no proven technologies exist to achieve the new mercury limit, the city applied to IDEM for a variance from the requirement. To accommodate the many communities needing such a variance, the Indiana Water Pollution Control Board recently adopted a streamlined variance rule for mercury. The rule provides for a streamlined process for obtaining a variance from the existing mercury effluent limit because of the lack of economically viable, end-of-pipe treatment options and the widespread existence of mercury in the environment. The rule establishes the conditions under which a variance will be granted and requirements for mercury minimization in wastewater discharges. The city is implementing a mercury minimization program to satisfy the requirements associated with the streamlined mercury variance rule.

Polychlorinated Biphenyls (PCBs) are complex organic compounds developed for use as synthetic oils and cooling fluids for transformers and capacitors. PCBs are a concern along the entire West Fork of the White River, including upstream of Marion County in Randolph, Delaware and Hamilton counties. Due to their complex chemistry, PCBs take an extremely long time to break down in nature. Because PCBs are complex (they persist in the environment) and organic (they have an affinity for other organic compounds), they tend to accumulate within stream sediments and the fatty tissue of fish. The manufacture of PCBs in the U.S. was discontinued in the late 1970s and their use and disposal strictly controlled. Therefore, a majority of the PCB load on the White River is from existing sediment loads, which cannot be controlled through the NPDES process or CSO control.

2.3.4 Other Metals and Organics

The 1981 USGS report titled *Preliminary Water-Quality Assessment of the Upper White River Near Indianapolis* assessed both metals and organic contaminants in bottom sediments. The report noted that chromium, copper, lead, mercury and zinc had accumulated in bottom materials of the White River downstream from 30th Street (river-mile 235.58). The source of the metals was believed to be from stormwater runoff and from combined sewer overflows. While the report indicated that some metals had accumulated on bottom materials of the White River, the availability of these sediment-bound constituents to aquatic organisms, the water column, and possibly man remains unknown.

In 1981, a USGS study also reported the presence of three pesticides and chlorinated hydrocarbons present in White River sediment. Chlordane, an insecticide; DDD, a degradation product of the insecticide DDT; and PCBs were reported in the parts per billion levels in sediment from the Washington Street sampling location. It was noted that before the ecological effect of pesticides and related organic compounds could be determined, additional information would be needed: (1) the physiological and ecological characteristics of the organisms present and (2) the chemical forms of the sorbed metals. A discussion of pesticide levels in stream and groundwater is provided in the USGS Circular 1150 titled “Water Quality in the White River Basin, Indiana, 1992-1996” (Fenelon, 1998). It was noted that agriculture is the major land use in the White River basin, and most pesticides detected in streams and groundwater during the study period were used primarily in agriculture. Consequently, pesticide concentrations in streams in the White River basin follow a seasonal pattern (Crawford and others, 1995).

2.3.5 Impaired Biotic Communities

The significant studies of aquatic biota and stream ecology in the White River and its tributaries in the Indianapolis area are:

- Biological Assessment of Streams in the Indianapolis Metropolitan Area, Indiana, 1999–2001 (USGS Water-Resources Investigations Report 03–4331, Voelker, 2004)
- Benthic Invertebrates and Quality of Streambed Sediments in the White River and Selected Tributaries In and Near Indianapolis, Indiana, 1994-96 (USGS Water Resources Investigations Report 99-4276, Renn and Voelker, 2000)
- Indianapolis Fish Kill Study (CDM, 1995)
- Water Quality Studies of the White River and its Tributaries (Commonwealth Technologies, 1993)

The most recent and comprehensive studies of the aquatic biota/ecology in the area are the 1994-1996 and the 1999-2001 USGS studies. Key findings are:

- The concentration of some metals, pesticides and organic compounds are elevated in the streambed sediments in the downtown Indianapolis area.
- Some of the elevated concentrations are high enough to adversely affect aquatic organisms.
- Benthic invertebrate communities at most sites in Marion County show some impact due to organic pollution and other contaminants, especially during periods of low streamflow. These impacts are generally most severe in the White River and tributaries in the downtown Indianapolis area.

2.3.6 Water Quality Improvements Due to Advanced Wastewater Treatment

A 1991 USGS study analyzing data from 1976 to 1986 found that advanced wastewater treatment (removal of ammonia) at the Belmont and Southport AWT plants led to significant improvements in water quality from 1978 to 1986. Based on a statistical analysis of data from four sites on the White River, the analysis compared water quality during pre-advanced (1978-1980) and post-advanced (1983-1986) wastewater treatment conditions. Water quality data from 1981-82 were omitted from the analysis because of variability due to plant construction.

Analysis of data from the two plants and downstream from the plants showed a significant decrease in concentrations of BOD, total suspended solids (TSS), ammonia, bacteria, and phosphorus. The decrease in BOD, TSS and ammonia due to implementation of advanced wastewater treatment resulted in a statistically significant increase in DO levels in the White River.

2.4 Water Quality Analysis of Marion County Waterways

2.4.1 Data Sources and Analysis Methods

The city reviewed in-stream water quality data for the West Fork of the White River and its tributaries for use in performing a total maximum daily load (TMDL) analysis.[1] The TMDL data analysis and conclusions also apply to the characterization of water quality conditions related to CSO long-term control planning, and therefore are summarized here. This section describes the data collected to review and assess compliance for each parameter of concern on the CSO-impacted waterways in and downstream of Marion County. In-stream water quality data was obtained from the following sources:

- City of Indianapolis Department of Public Works Office of Environmental Services (OES)
- Marion County Health Department (MCHD)
- Indiana Department of Environmental Management (IDEM) (White River and Fall Creek only)

[1]Section 303(d) of the Clean Water Act requires the development of Total Maximum Daily Loads (TMDLs) for waters that a state has identified as being impaired. A TMDL determines the amount of a specific pollutant discharged into a water body that can be assimilated and still meet water quality standards.

E. coli bacteria data for 2000-2002 as analyzed for compliance with:

- IDEM's geometric mean water quality standard for *E. coli* bacteria (125 cfu/100 mL or less)
- IDEM's 303(d) Listing Methodology (2002) guidance that no more than 10 percent of samples be above 235 cfu/100 mL
- IDEM's 303(d) Listing Methodology (2002) guidance of no sample having an *E. coli* bacteria count greater than 10,000 cfu/100 mL

In order to better analyze *E. coli* sampling results, data was separated into wet-weather and dry-weather categories. Wet weather was defined as days on which precipitation fell (greater than 0.1 inch) and the three days following that precipitation. The three-day period was determined by an analysis of *E. coli* bacteria in stormwater and CSOs during development of the April 2001 LTCP. Dry weather was defined as any time other than wet weather.

Data for each parameter were collected at various intervals and locations by the three agencies between 2000 and 2002. The data was evaluated for compliance with the Indiana Surface Water Quality Standards as set in the Indiana Administrative Code (327 IAC 2-1-6) for each parameter. The following subsections summarize the findings for each waterway reviewed.

2.4.2 White River (West Fork)

2.4.2.1 Cyanide

An earlier analysis indicated that the primary source of cyanide in this portion of the White River is the city's Belmont and Southport AWT plants, which receive and treat cyanide from industrial users. In-stream water quality monitoring data supports this finding.

2.4.2.2 Dissolved Oxygen

Dissolved oxygen data was collected at 17 locations on the White River at varying intervals ranging from monthly to weekly from January 2000 to December 2001. The data for 16 out of 17 stations showed 100 percent compliance with the Indiana DO standard of 4 mg/L minimum and 5 mg/L average per day. The one exception was at the New York Street station, where there was one occurrence of being below the standard of 4 mg/L. **Figure 2-16** presents this information. In addition to the grab samples, OES also deployed continuous dissolved oxygen and temperature probes at three locations on the White River: 16th Street, Indianapolis

Power and Light (IPL), and Waverly (SR 144) from June to December (1998 to present).[2] The IPL monitoring station achieved 100 percent compliance with the DO minimum value of 4 mg/L, while the Waverly and 16th Street stations achieved 96 percent and 99 percent compliance, respectively. Compliance with the daily average of 5 mg/L was 100 percent at 16th Street, 99.3 percent at IPL, and 98.7 percent at Waverly. **Figures 2-17** through **2-20** present this information. Daily averages for the sample data are presented in **Figures 2-21** through **2-23**. Some data has been flagged as "questionable" by the agency collecting the data. The city did not use questionable data in determining the above compliance rates.

Dissolved oxygen content that is less than the Indiana minimum in-stream water quality standard of 4 mg/L is believed to be caused by CSO discharges for this river segment. Dissolved oxygen concentrations frequently drop as oxygen is consumed by oxygen-demanding materials from combined sewer overflows, urban runoff, resuspended sediment, and anoxic water from combined sewer overflows (USGS, 1995).

2.4.2.3 *E. coli* Bacteria

The city analyzed *E. coli* bacteria sampling data for January 2000 to December 2001 from OES, MCHD, and IDEM. In addition, the TMDL project utilized data from 2002 where available. Compliance with the single sample maximum *E. coli* standard (235 cfu/100 mL) generally decreases when moving from the upstream boundary at 96th Street (64 percent compliance) to the downstream boundary at Waverly (21 percent). Only the New York Street sampling location has sufficient sampling frequency (5 samples in 30 days) for a geometric mean comparison. During 2001, that station did not meet the geometric mean monthly standard of 125 cfu/100 mL. **Figures 2-24** through **2-39** present this information. Some data has been flagged as "questionable" by the agency collecting the data. The city did not use questionable data in determining the above compliance rates.

In addition, the White River was divided into three segments for *E. coli* analysis purposes:

- White River North: Upstream Marion County line to Interstate 65 (upstream of CSO area),
- White River CSO Area: Interstate 65 to Tibbs/Banta Landfill, and
- White River South: Tibbs/Banta Landfill to Waverly (downstream of CSO area).

Figure 2-40 shows the geographic extent of each analyzed river segment. The segment between the upstream Marion County Line to Lake Indy is considered upstream of the CSO area since the two CSOs that discharge within that area are only active an average of once per year.

The findings of the compliance analysis are presented in **Table 2-2** and described in the text below for the three segments on the White River for all weather, dry weather, and wet weather.

2.4.2.3.1 All-Weather Analysis

All three river segments exceed the *E. coli* bacteria geometric mean standard of 125 cfu/100 mL, and the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL and no samples in excess of 10,000 cfu/100 mL. The analysis suggests that all segments of the White River are not able to assimilate the *E. coli* bacteria load from wildlife, failed septic systems, stormwater, and CSO sources. However, the White River upstream of Interstate 65 comes closest to meeting the Indiana geometric mean standard of 125 cfu/100 mL.

2.4.2.3.2 Dry-Weather Analysis

During dry weather, two of the river segments – from 96th Street to Tibbs/Banta Landfill – have *E. coli* bacteria geometric mean values lower than the Indiana standard of 125 cfu/100 mL. However, neither river segment meets the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL during dry weather. The analysis suggests that the White River through the CSO area has sufficient baseflow to absorb the *E. coli* bacteria load during a "typical" dry-weather day; however, frequent low flow conditions or fluctuations in the septic or wildlife loads occur more than 10 percent of the time during dry weather. The White River segment downstream of the CSO area exceeds both the Indiana geometric mean standard of 125 cfu/100 mL and the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL during dry weather. The analysis suggests that the stream receives excessive *E. coli* bacteria loadings from failed septics, illicit connections and wildlife sources.

2.4.2.3.3 Wet-Weather Analysis

All of the river segments exceed all criteria during wet weather. The analysis suggests that all segments of the White River receive excessive *E. coli* bacteria loadings from stormwater and CSO sources. The number of samples in excess of 10,000 cfu/100 mL for the White River CSO area is

[2] DO data was not collected in 2000 at the 16th Street site.

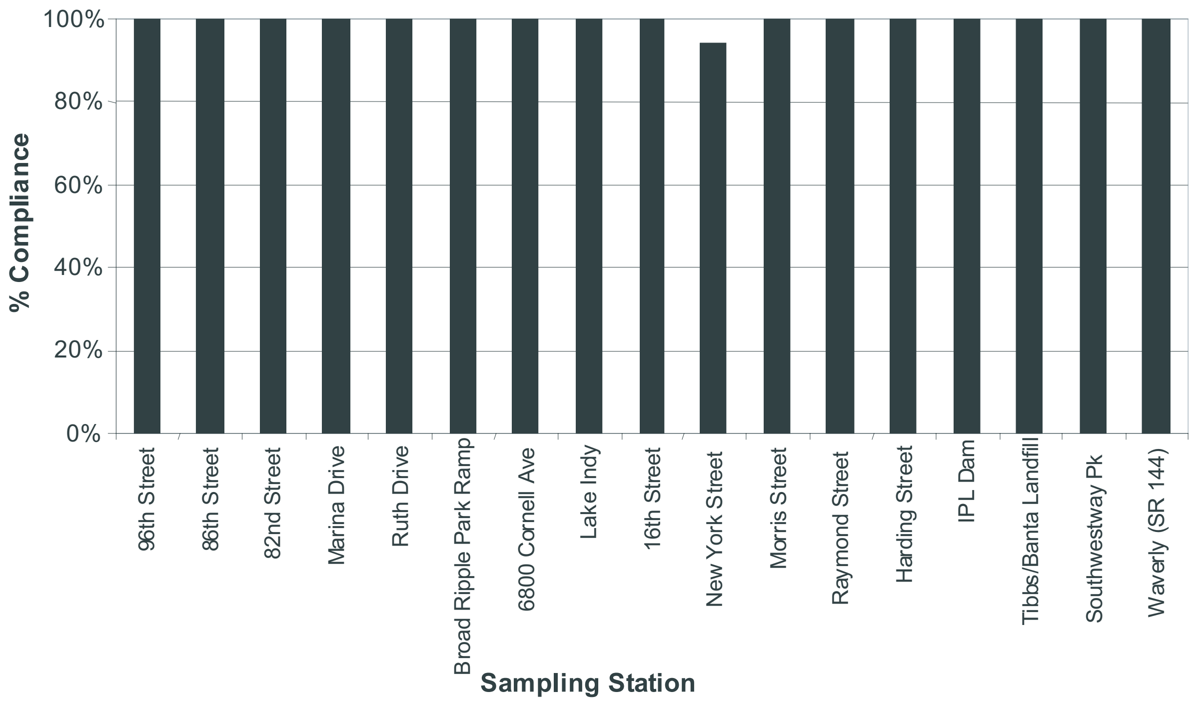

Figure 2-16
White River: Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L

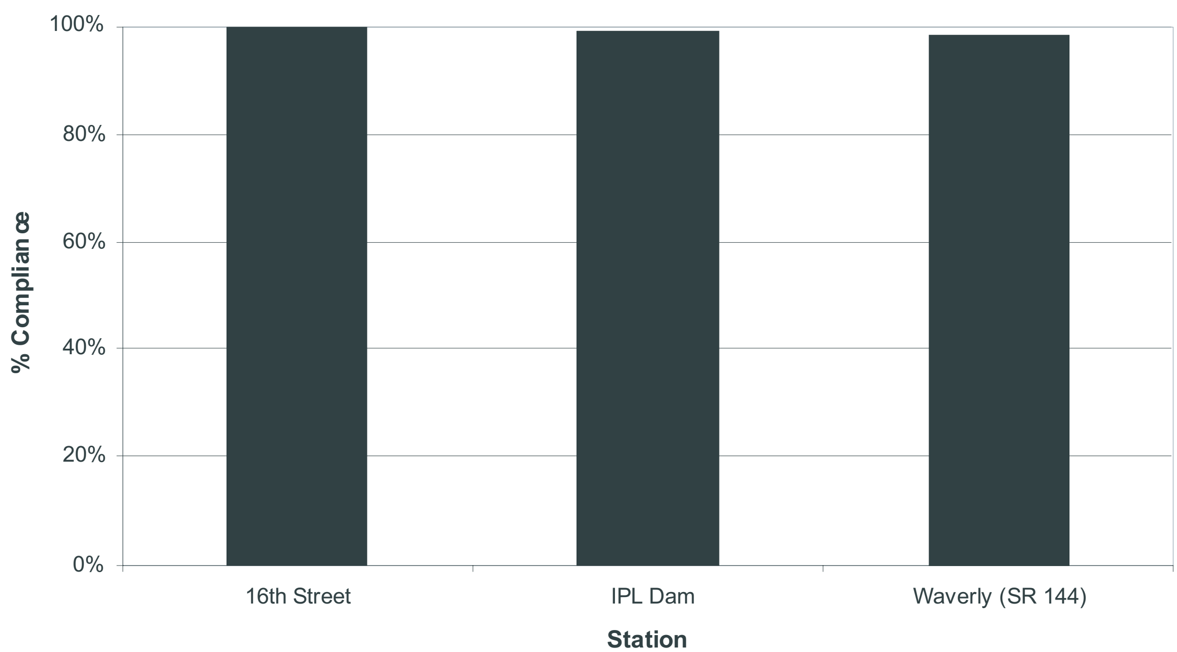

Figure 2-17
White River: Percent Compliance with Indiana Dissolved Oxygen Standard of 5 mg/L Average Daily Value

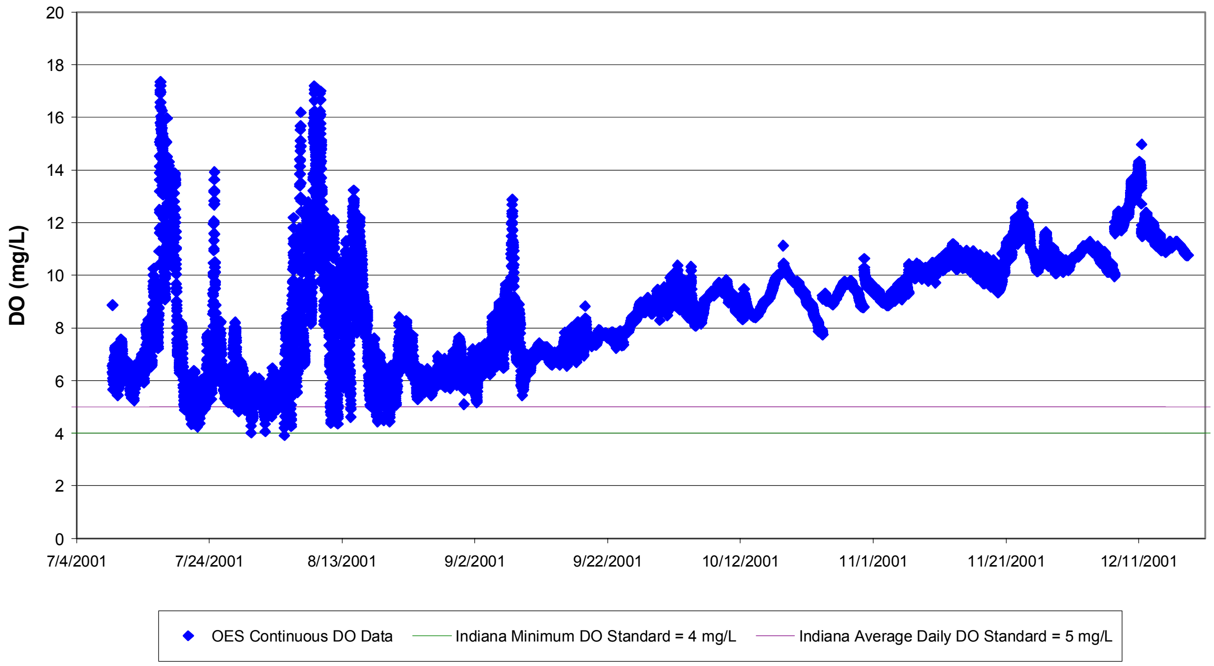

Figure 2-18
White River Continuous Dissolved Oxygen Data: 16th Street
City of Indianapolis OES Continuous DO Meter Location
(July 2001 to December 2001)

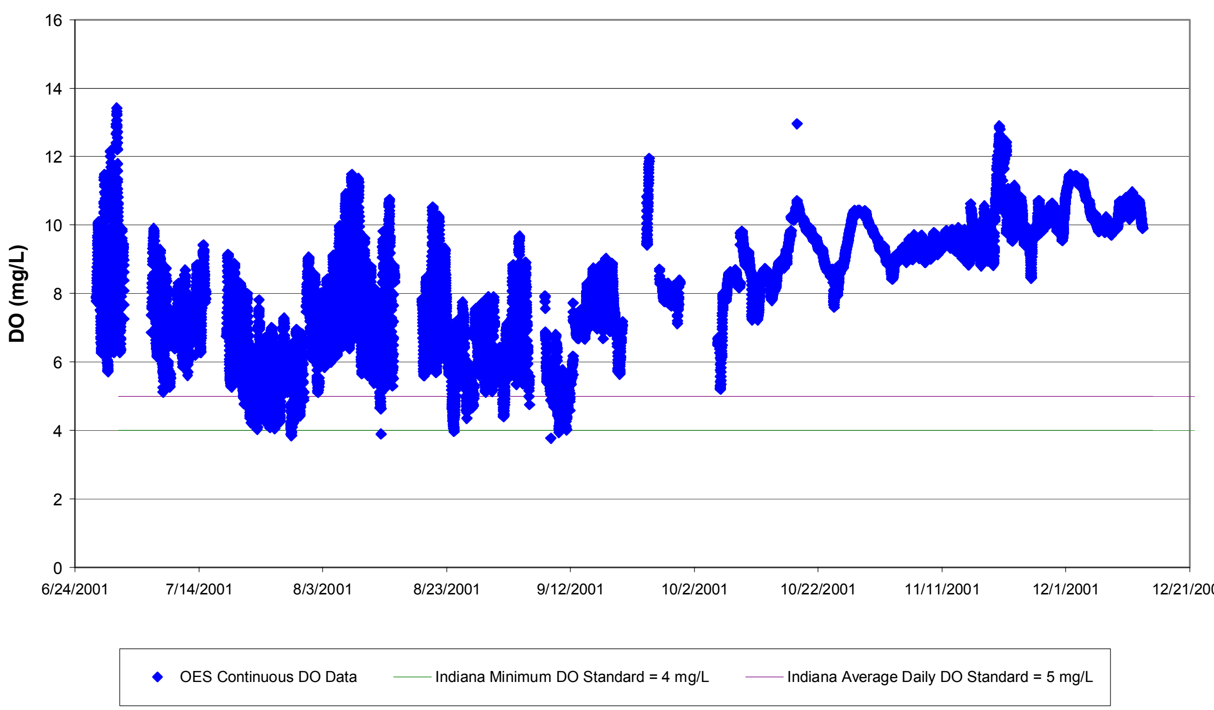

Figure 2-19
White River Continuous Dissolved Oxygen Data: Waverly (SR 144)
City of Indianapolis OES Continuous DO Meter Location
(July 2001 to December 2001)

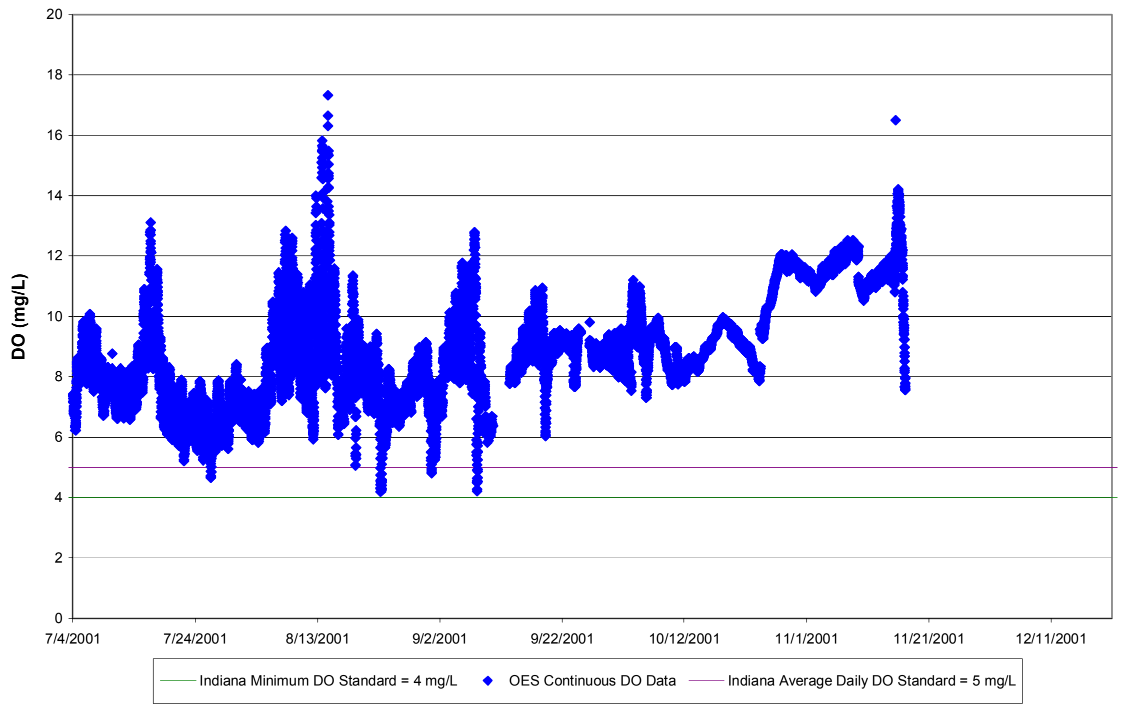

Figure 2-20
White River Continuous Dissolved Oxygen Data: IPL Station
City of Indianapolis OES Continuous DO Meter Location
(July 2001 to December 2001)

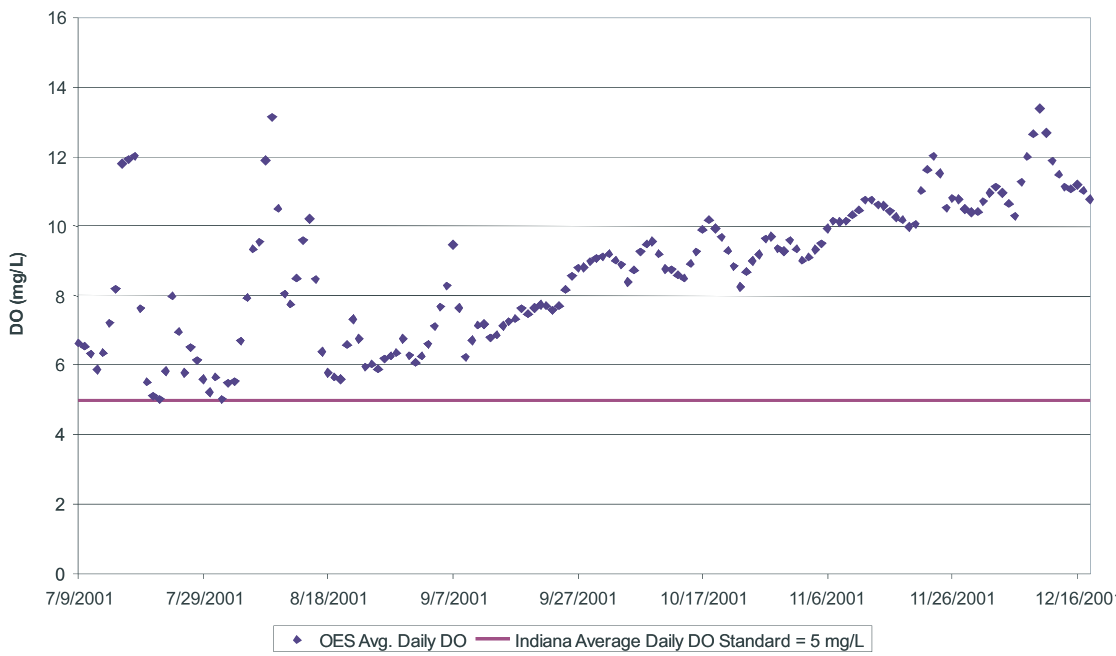

Figure 2-21
White River Average Daily Continuous Dissolved Oxygen Data: 16th Street
City of Indianapolis OES Continuous DO Meter Location
(July 2001 to December 2001)

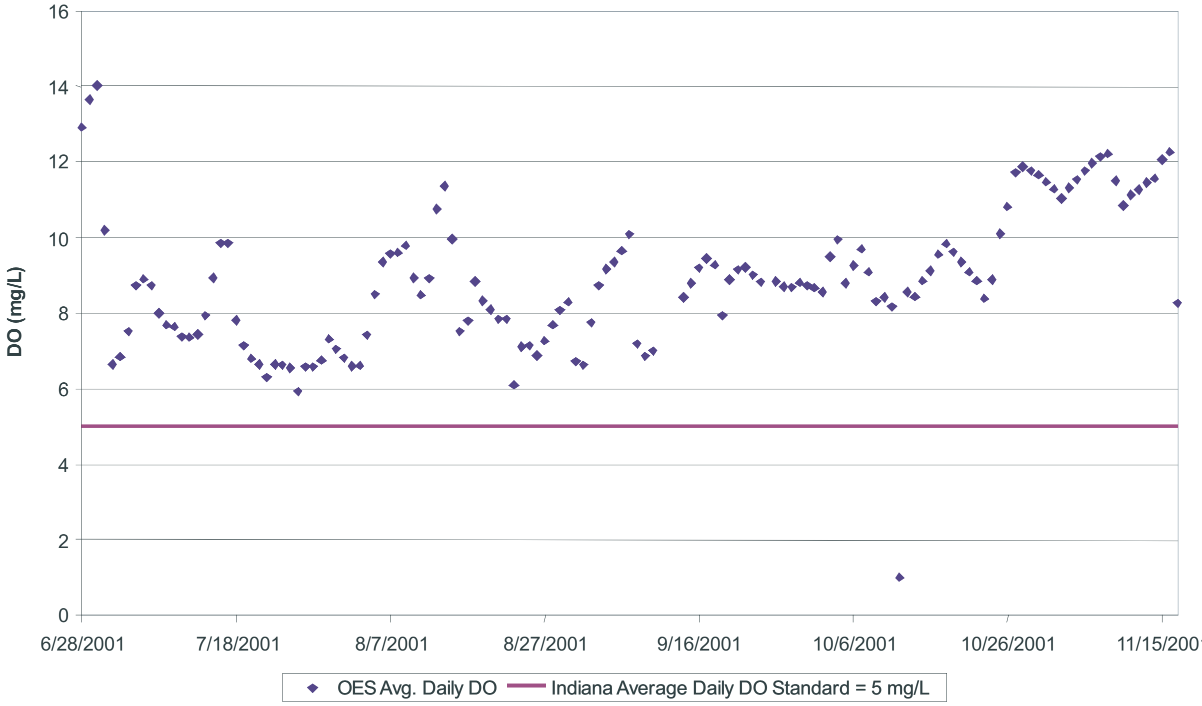

Figure 2-22
White River Average Daily Continuous Dissolved Oxygen Data: IPL Station
City of Indianapolis OES Continuous DO Meter Location
(July 2001 to December 2001)

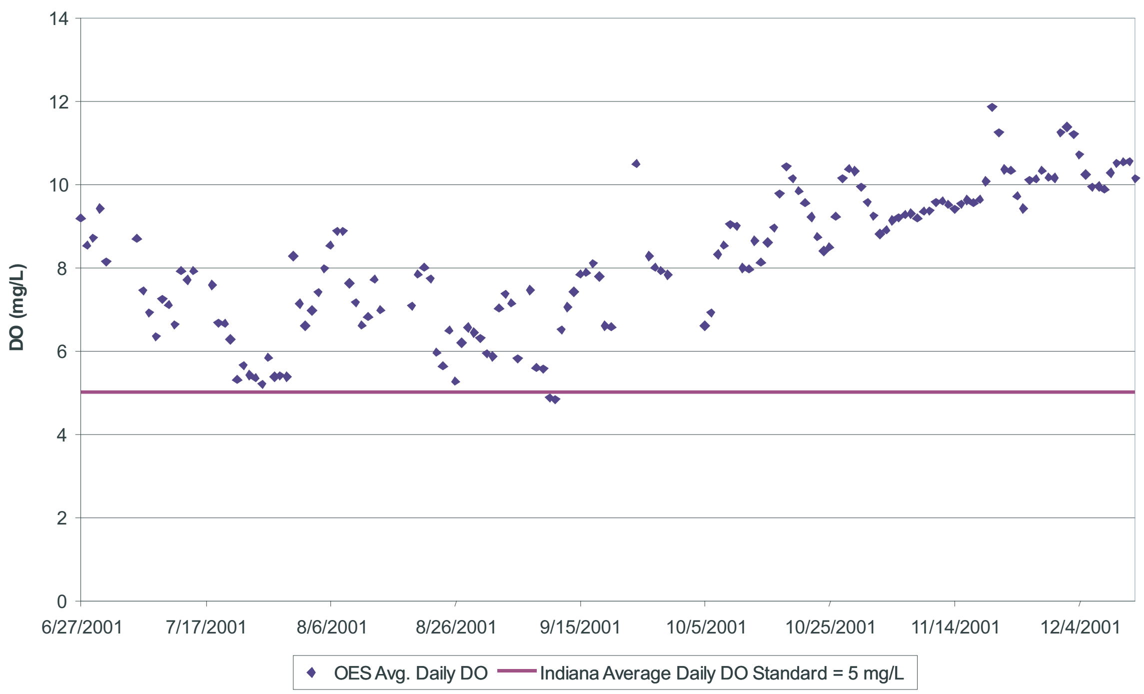

Figure 2-23
White River Average Daily Continuous Dissolved Oxygen Data: Waverly (SR 144)
City of Indianapolis OES Continuous DO Meter Location
(July 2001 to December 2001)

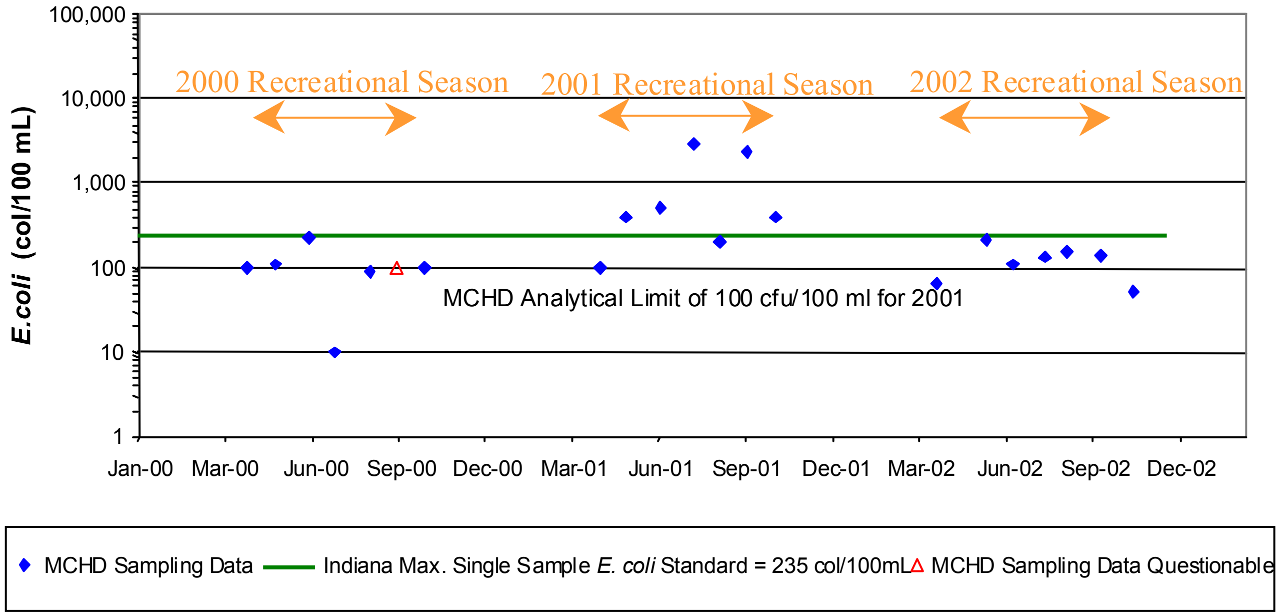

Figure 2-24
White River *E. coli* Data: 96th Street
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

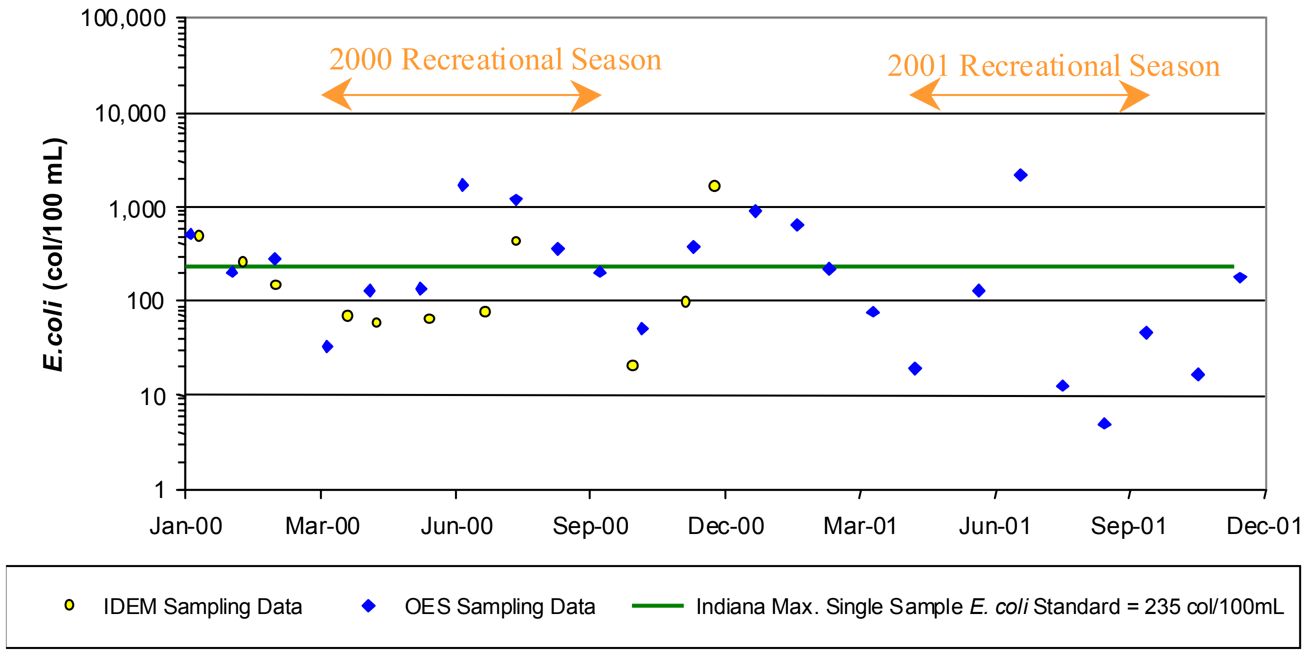

Figure 2-25
White River *E. coli* Data: 82nd/86th Street
IDEM & OES Sampling Site
(April 2000 to October 2001)

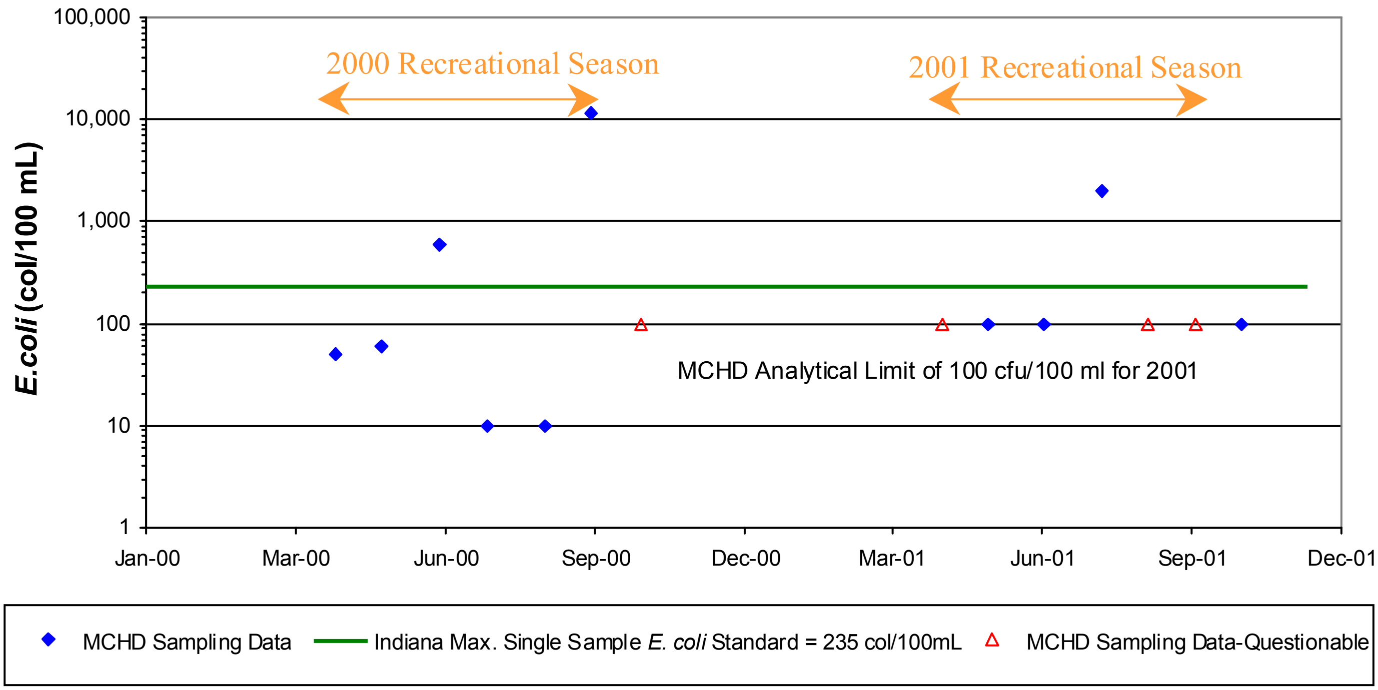

Figure 2-26
White River *E. coli* Data: Marina Drive
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2001)

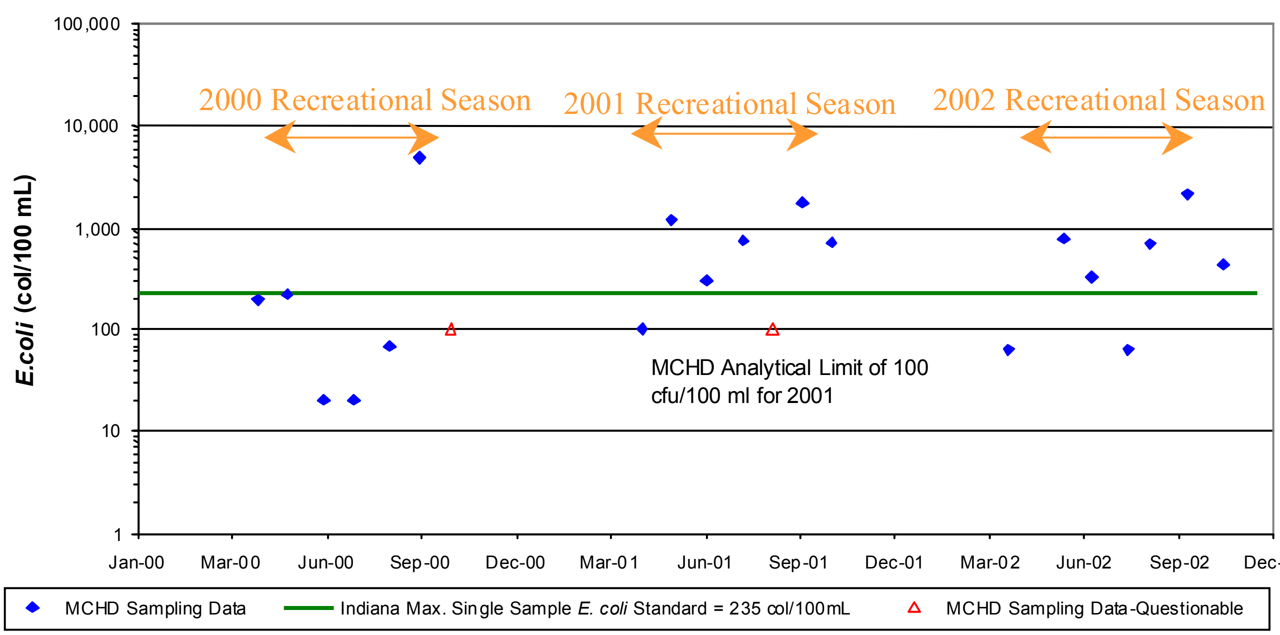

Figure 2-27
White River *E. coli* Data: Ruth Drive
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

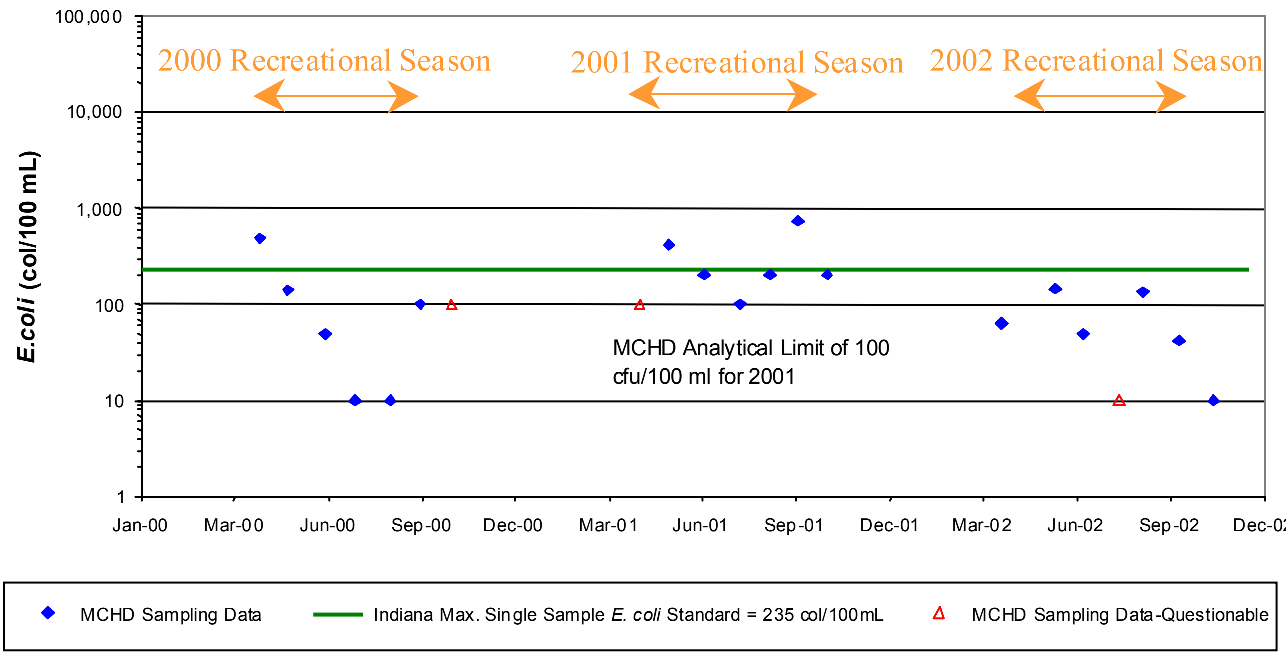

Figure 2-28
White River *E. coli* Data: Broad Ripple Park Ramp
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

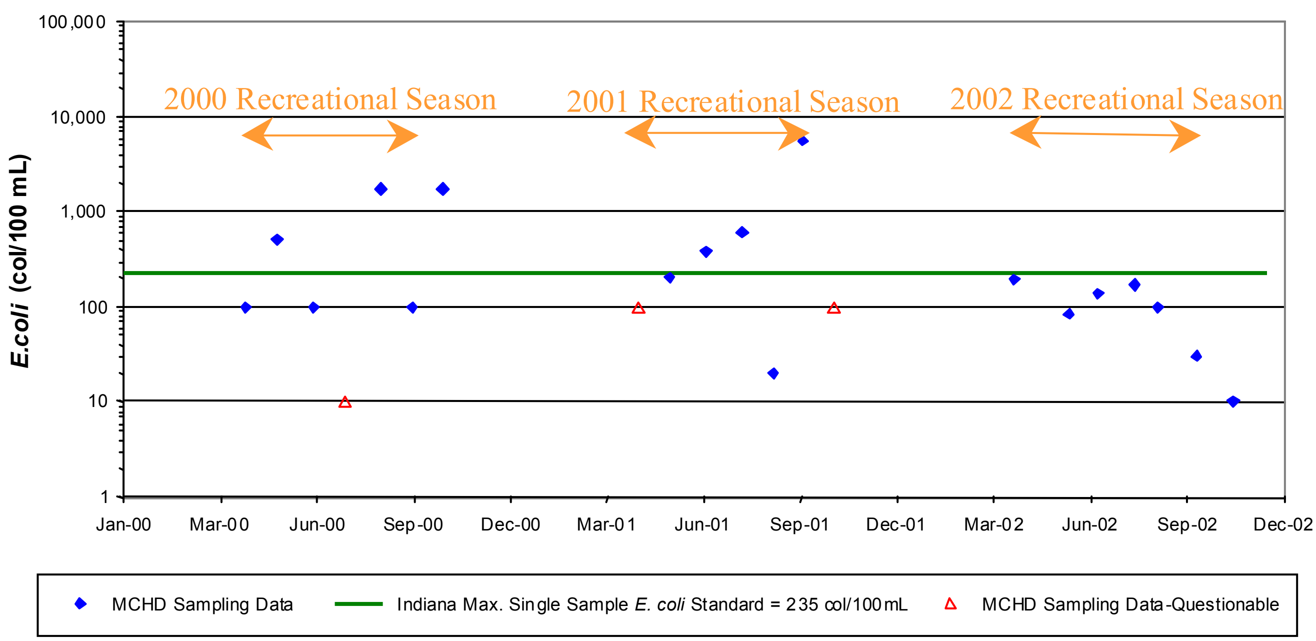

Figure 2-29
White River *E. coli* Data: 6800 Cornell Avenue
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

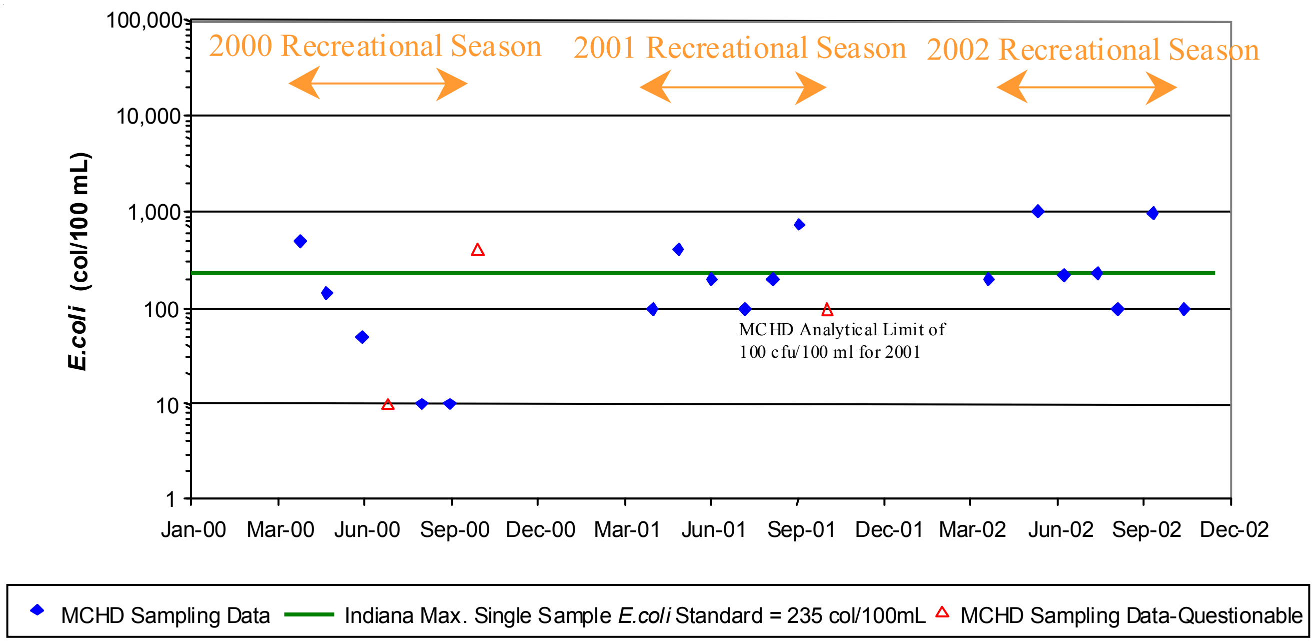

Figure 2-30
White River *E. coli* Data: Lake Indy
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

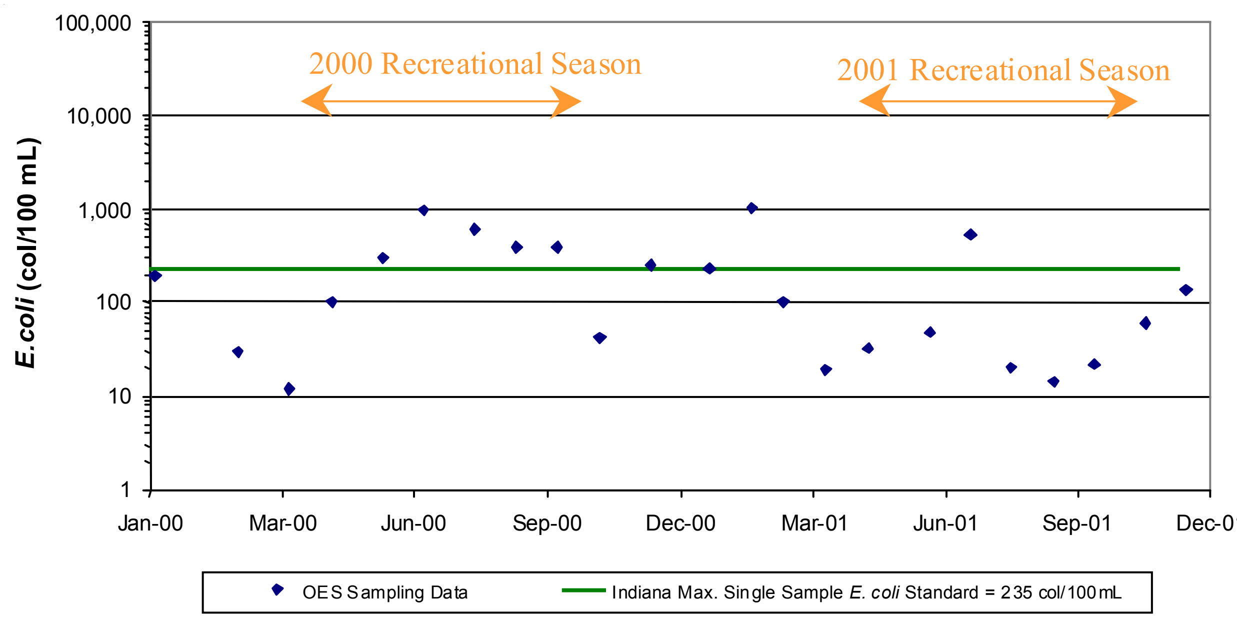

Figure 2-31
White River *E. coli* Data: 30th Street
City of Indianapolis OES Sampling Site (January 2000 to December 2001)

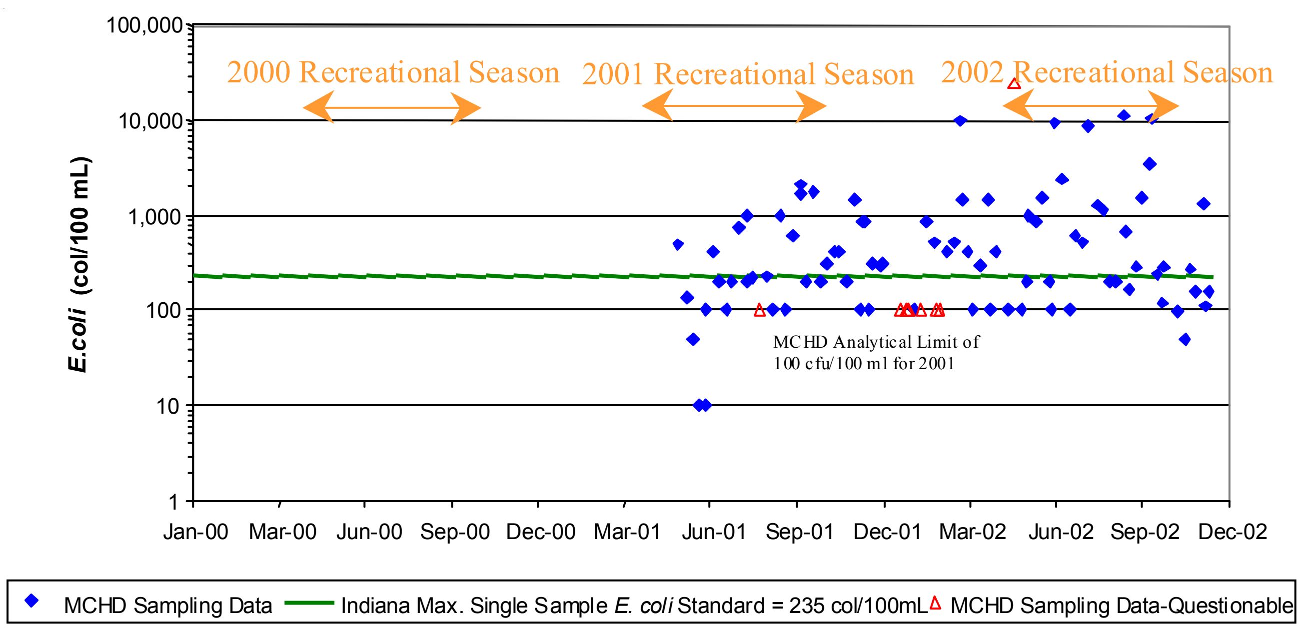

Figure 2-32
White River *E. coli* Data: New York Street
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

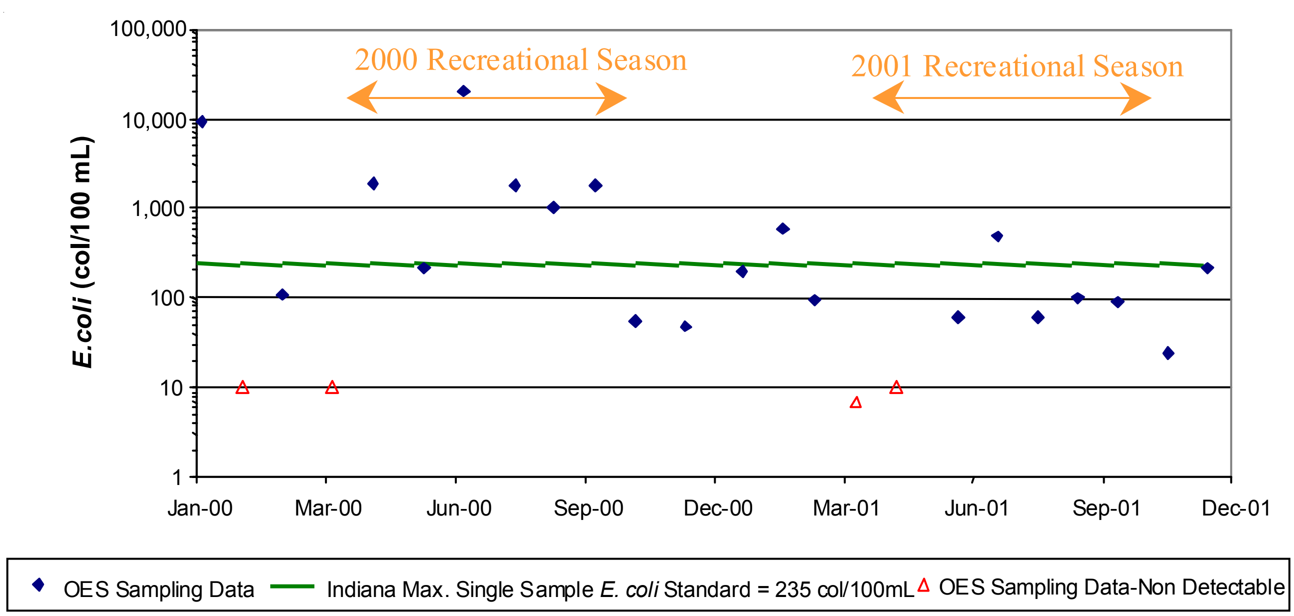

Figure 2-33
White River *E. coli* Data: Morris Street
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

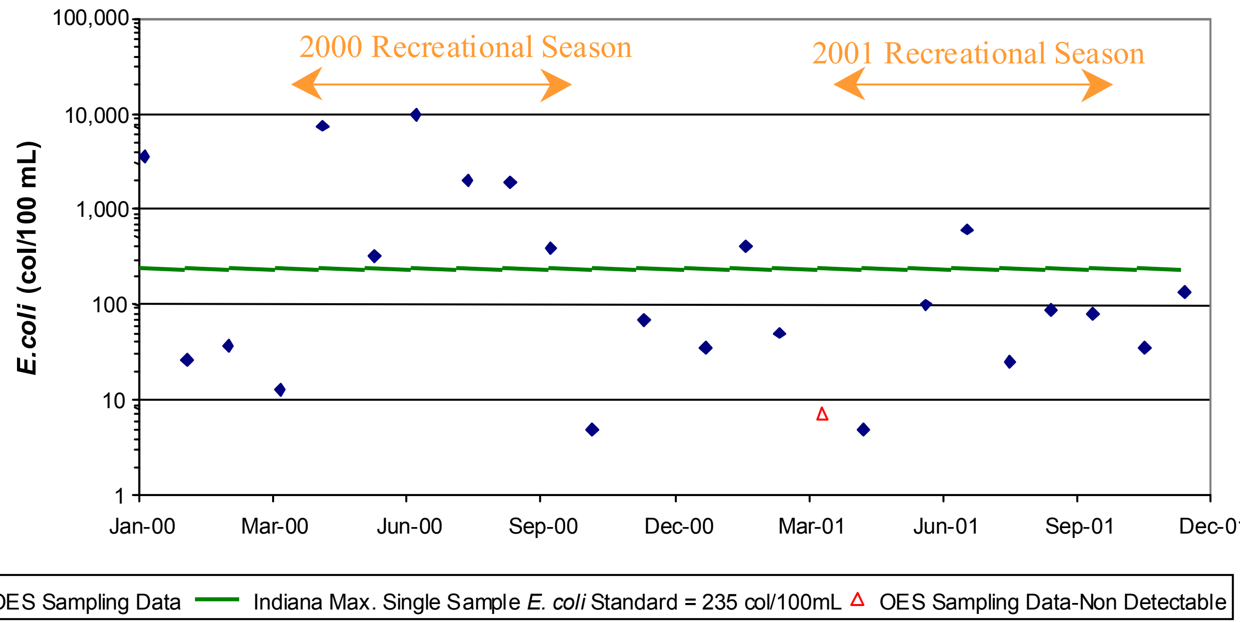

Figure 2-34
White River *E. coli* Data: Harding Street
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

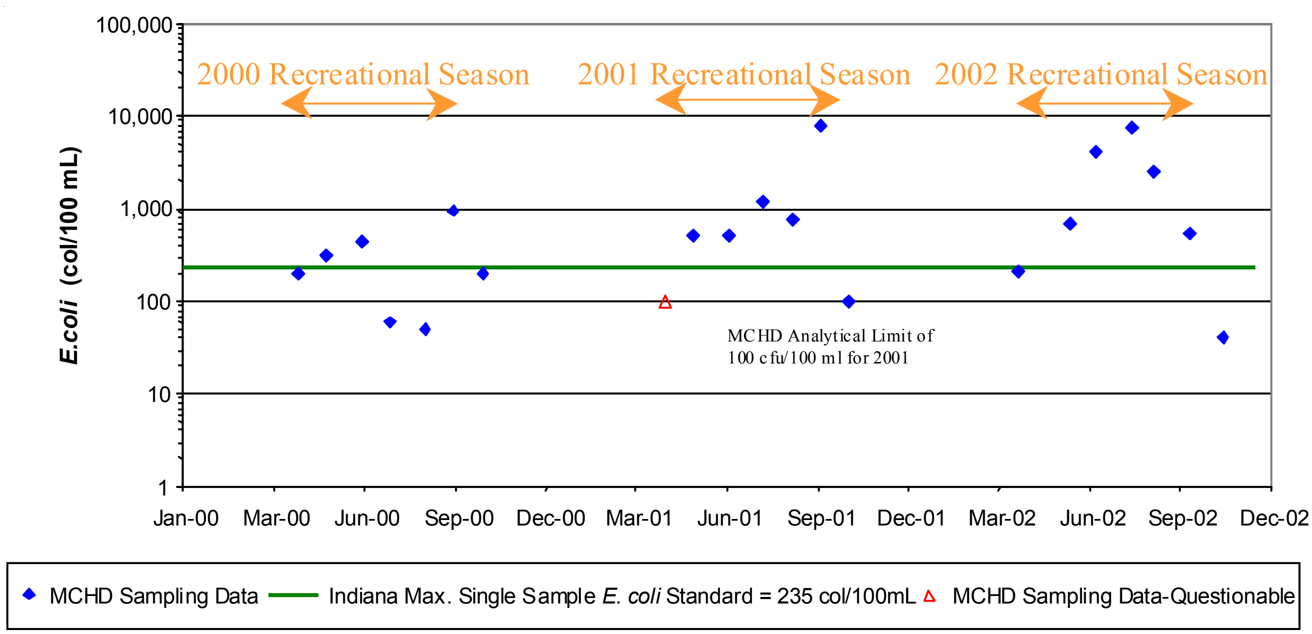

Figure 2-35
White River *E. coli* Data: Raymond Street
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

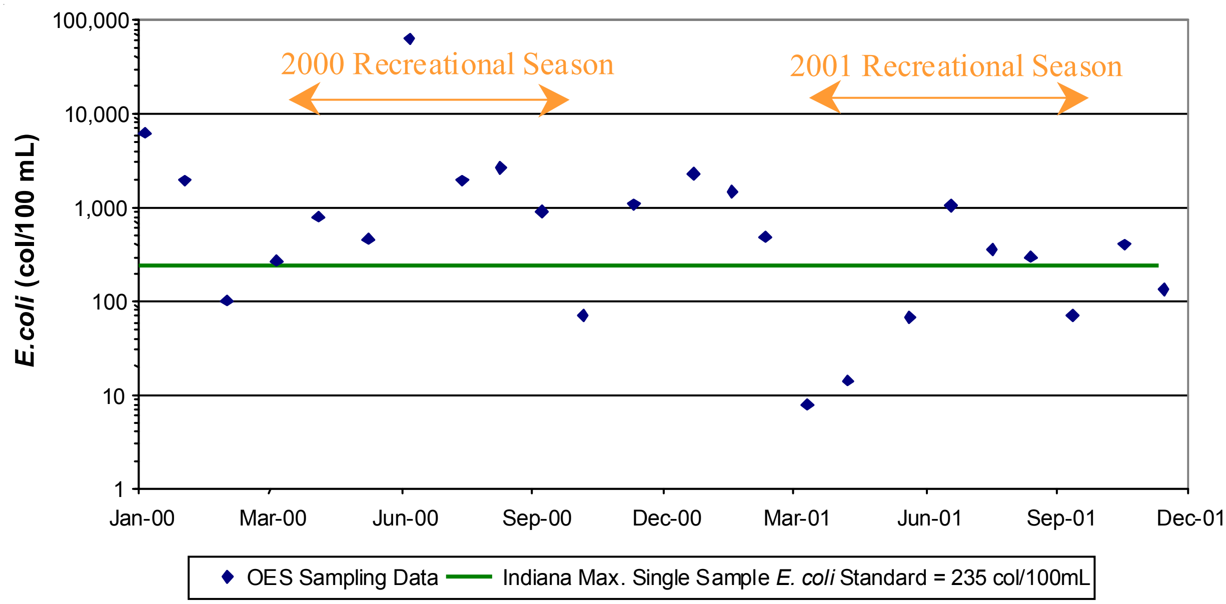

Figure 2-36
White River *E. coli* Data: Tibbs/Banta Landfill
Marion County Health Department (MCHD) Sampling Site
(April 2000 to October 2002)

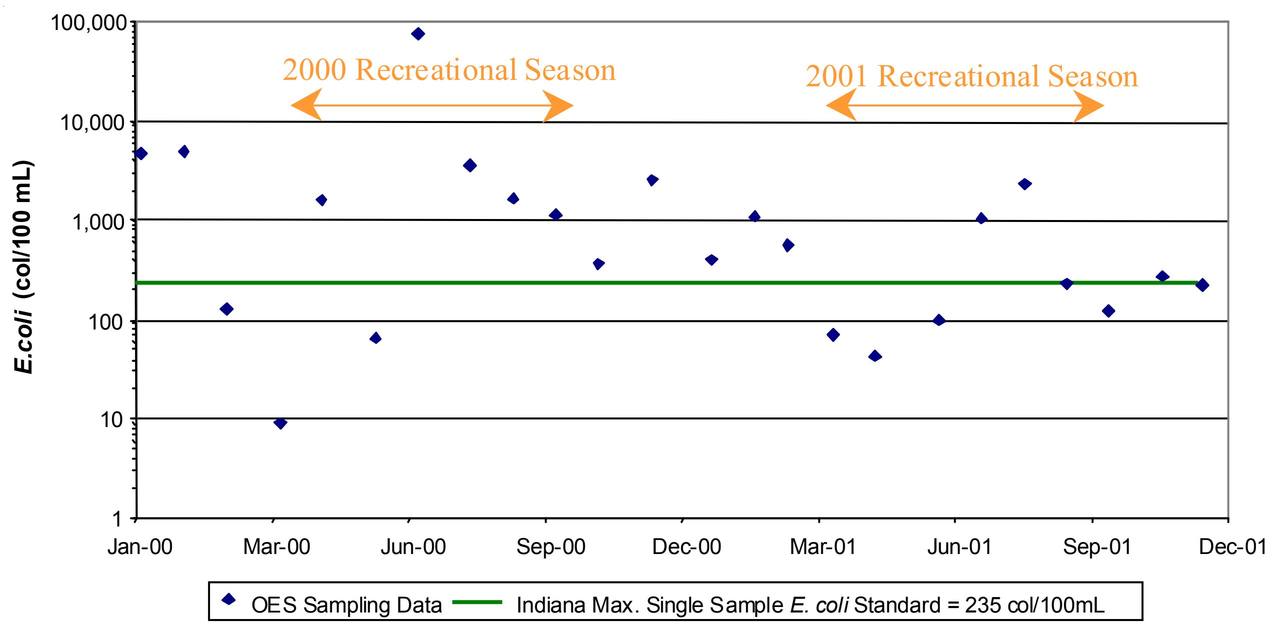

Figure 2-37
White River *E. coli* Data: Southwestway Park
City of Indianapolis OES Sampling Site
(January 2000 to December 2001)

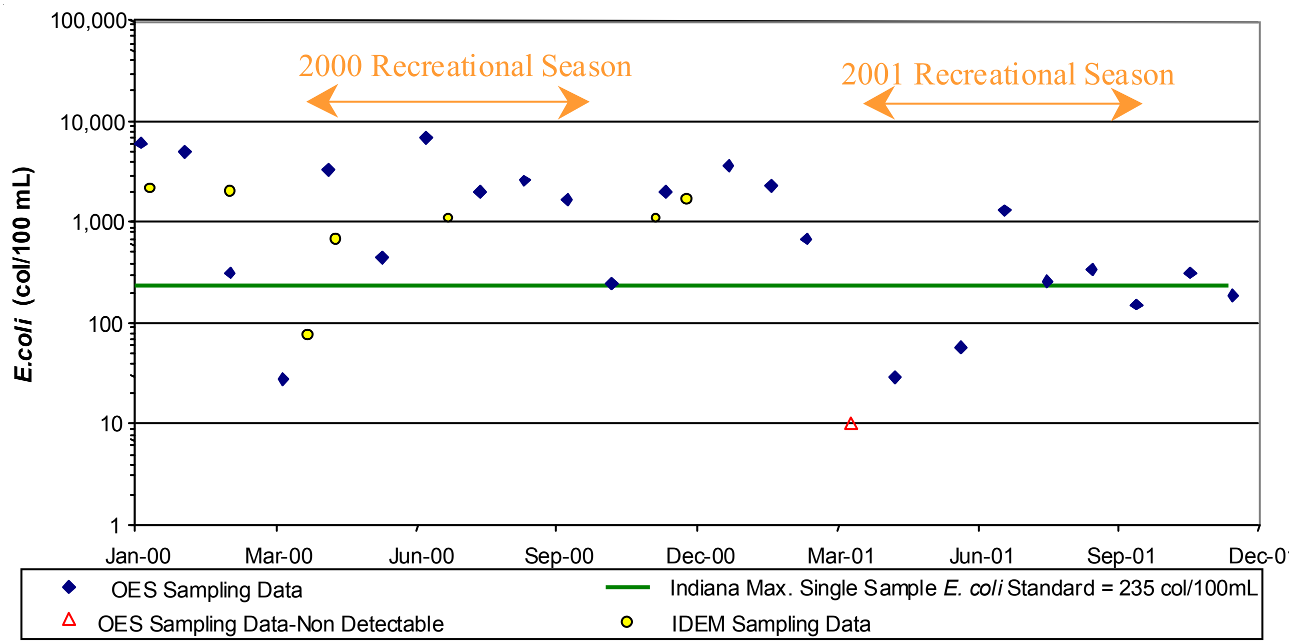

Figure 2-38
White River *E. coli* Data: Waverly (SR 144)
City of Indianapolis OES Sampling Site
(January 2000 to December 2001)

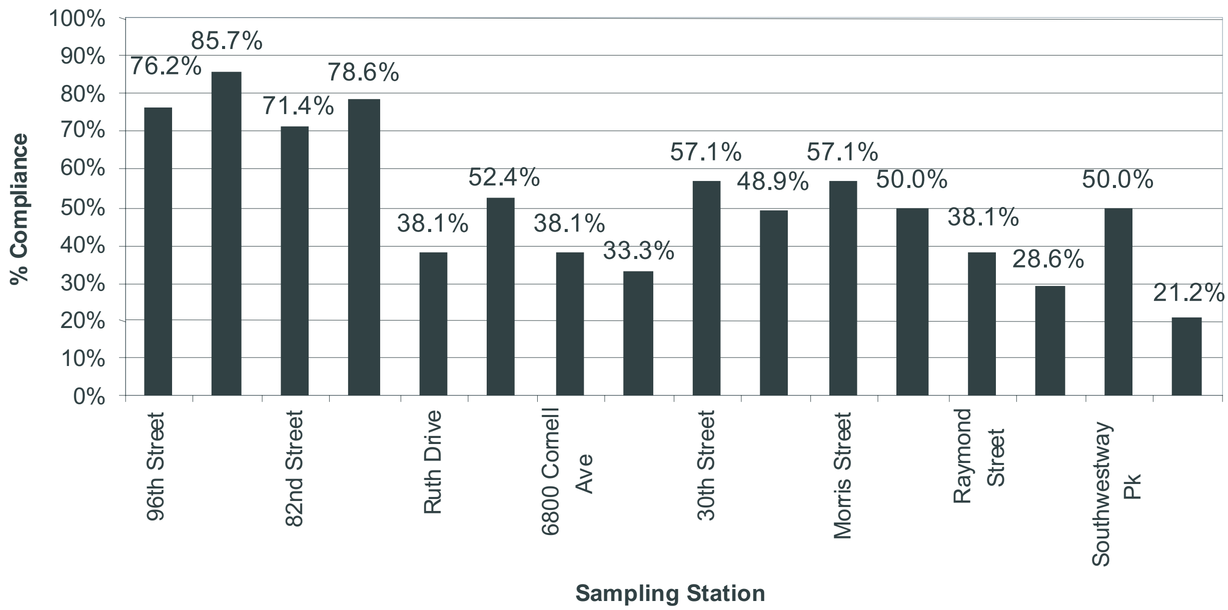

Figure 2-39
Percent Compliance with Indiana Single Sample Maximum *E. coli* Bacteria Standard of 235 cfu/100mL in the White River
April through October for 2000 and 2002
MCHD / City of Indianapolis

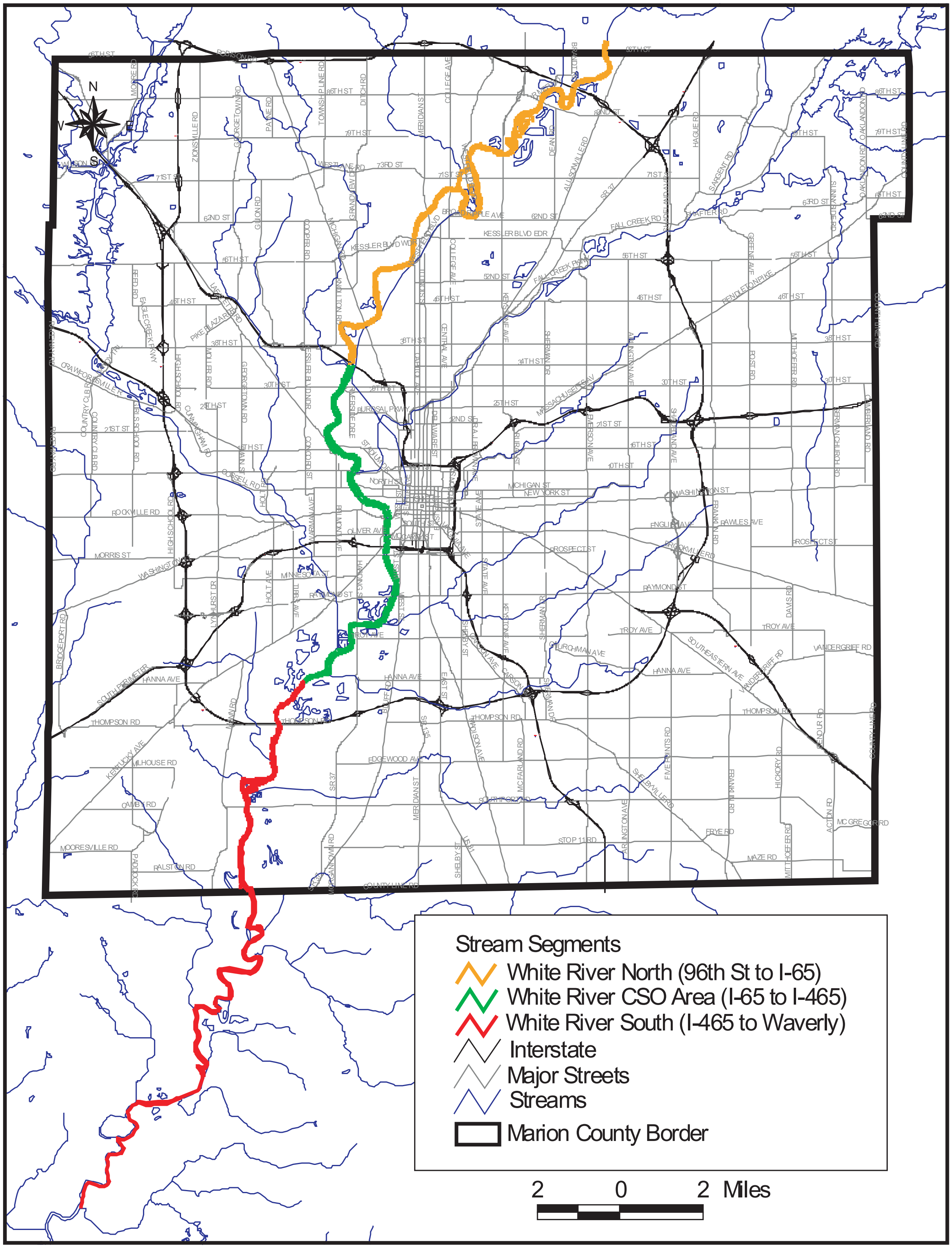

Figure 2-40
White River Stream Segments

Table 2-2
White River *E. coli* Bacteria Compliance

River Segment	Geometric Mean of 2000-2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
All Data				
White River - Upstream of Lake Indy	166	32.9%	1	155
White River - Within CSO Area	238	46.2%	4	184
White River - Downstream of CSO Area	410	63.8%	2	47
Dry Weather				
White River - Upstream of Lake Indy	74	19.1%	0	47
White River - Within CSO Area	99	25.3%	0	91
White River - Downstream of CSO Area	165	44.0%	0	25
Wet Weather				
White River - Upstream of Lake Indy	236	38.9%	1	108
White River - Within CSO Area	561	66.7%	4	93
White River - Downstream of CSO Area	1159	86.4%	2	22
State Guidance [1]	**(IDEM standard of 125 cfu/100 ml)**	**(IDEM Guidance 10% or less)**	**(IDEM Guidance None > 10,000 cfu/100 ml)**	

[1] **Indiana's 303(d) Listing Methodology for Impaired Waterbodies and Total Maximum Daily Load - September 2002**

less than that for the Fall Creek and Pleasant Run CSO areas during wet weather. This suggests that the White River possesses more baseflow to absorb the wet-weather load and avoid extremely high bacteria counts. However, the percent of samples in excess of the more stringent daily maximum standard of 235 cfu/100 mL for the White River CSO area is comparable to the Fall Creek and Pleasant Run CSO areas.

2.4.3 Fall Creek

2.4.3.1 Dissolved Oxygen

Dissolved oxygen (DO) data was collected at 13 locations on Fall Creek at varying intervals from monthly to weekly from January 2000 to May 2002. The data for nine stations out of the 13 showed 100 percent compliance with the Indiana minimum DO standard of 4 mg/L. The exceptions were located at 79th Street, 5700 Fall Creek Parkway North, 4500 Fall Creek Parkway North and 30th Street. **Figure 2-41** presents this information.

Dissolved oxygen concentrations that fall below the in-stream water quality standard at 30th Street are caused primarily by upstream CSO discharges. **Figure 2-42** presents continuous DO data from an August 30, 2001 storm event. The BOD load from the CSOs causes the DO to drop during the storm event. However, the 79th Street, 5700 Fall Creek Parkway North, and 4500 Fall Creek Parkway North stations, which are upstream of the CSO area, also report occurrences of DO below the standard of 4 mg/L. In this area above the CSOs, low streamflow appears to contribute to the exceedances of the DO standard.

2.4.3.2 *E. coli* Bacteria

Data collected between January 2000 and December 2001 (and 2002, where available) demonstrate that Fall Creek exceeds the Indiana water quality standard for *E. coli* bacteria.

- Forty-four percent of the sampling stations exceeded the daily maximum *E. coli* bacteria standard (235 cfu/100 mL) more than 50 percent of the time.
- Fifty percent of the sampling stations with sufficient data (five samples in 30 days) exceed the geometric mean *E. coli* bacteria standard (125 cfu/100 mL) at least 75 percent of the time.

E. coli bacteria exceedances occur at all stations on Fall Creek, as shown in data and compliance plots provided in **Figures 2-43** through **2-56**. The upstream sampling station at 79th Street has the best compliance with the bacteria standard; 100 percent of the time the in-stream value is less than the daily maximum limit of 235 cfu/100 mL. Some data has been flagged as "questionable" by the agency collecting the data. The city did not use questionable data in determining the above compliance rates.

Fall Creek was divided into two stream segments for analysis purposes:

- Fall Creek Upstream of the CSO Area (Geist Reservoir to Keystone Avenue)
- Fall Creek Within the CSO Area (Keystone Avenue to the West Fork of the White River)

In-stream *E. coli* bacteria sampling data were grouped for each segment. For informational purposes, data from major tributaries – Mud Creek, Lawrence Creek and Devon Creek – were also analyzed. **Figure 2-57** shows the geographic extent of each stream segment for Fall Creek and its tributaries.

The findings of the city's compliance analysis are presented in **Table 2-3** for the two Fall Creek stream segments, based upon all weather, dry-weather, and wet-weather data.

2.4.3.2.1 All-Weather Analysis

Two segments, upstream Fall Creek and Mud Creek, have monthly geometric mean *E. coli* values that meet the Indiana geometric mean standard of 125 cfu/100 mL. However, neither stream is in compliance with the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL, and Mud Creek had an observed count above 10,000 cfu/100 mL. The analysis suggests that Fall Creek upstream of the CSO area and Mud Creek (upstream of the CSO area) possess sufficient baseflow to absorb the *E. coli* bacteria load on a "typical" day, but receive excessive *E. coli* loadings from stormwater and failed septics during wet-weather or low-flow, dry-weather days. The other three segments – Fall Creek within the CSO area, Devon Creek, and Lawrence Creek – do not meet the geometric mean standard of 125 cfu/100 mL or the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL. The analysis suggests that these streams are not able to absorb the *E. coli* bacteria load from wildlife, failed septics, and stormwater sources. The 30 samples in excess of 10,000 cfu/100 mL in the Fall Creek CSO area segment in an 18-month period imply that CSOs are a significant source of *E. coli* bacteria loads to the stream.

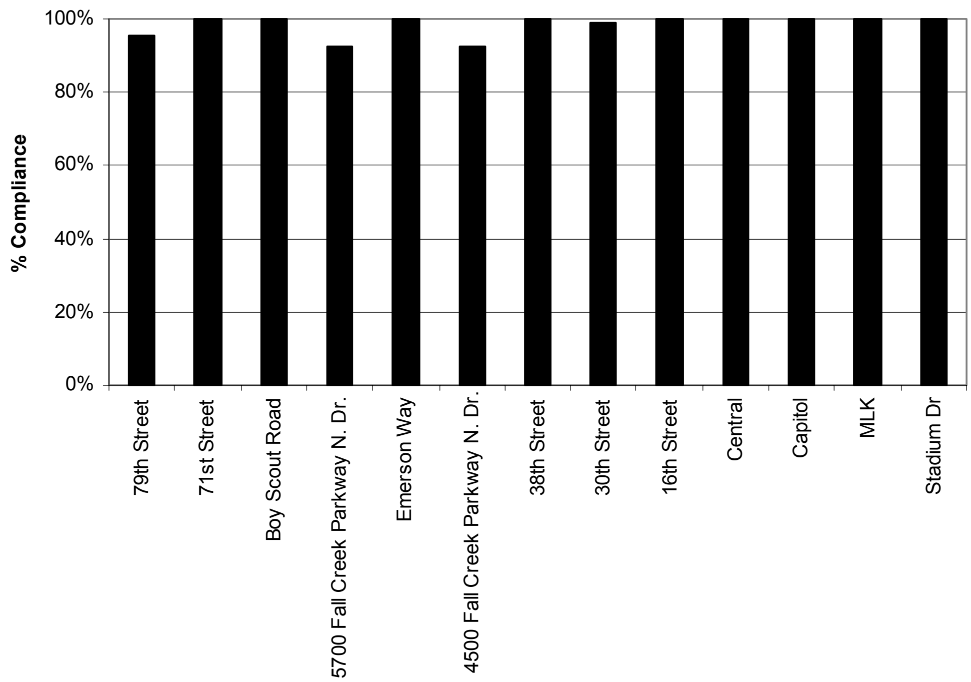

Figure 2-41
Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L in Fall Creek

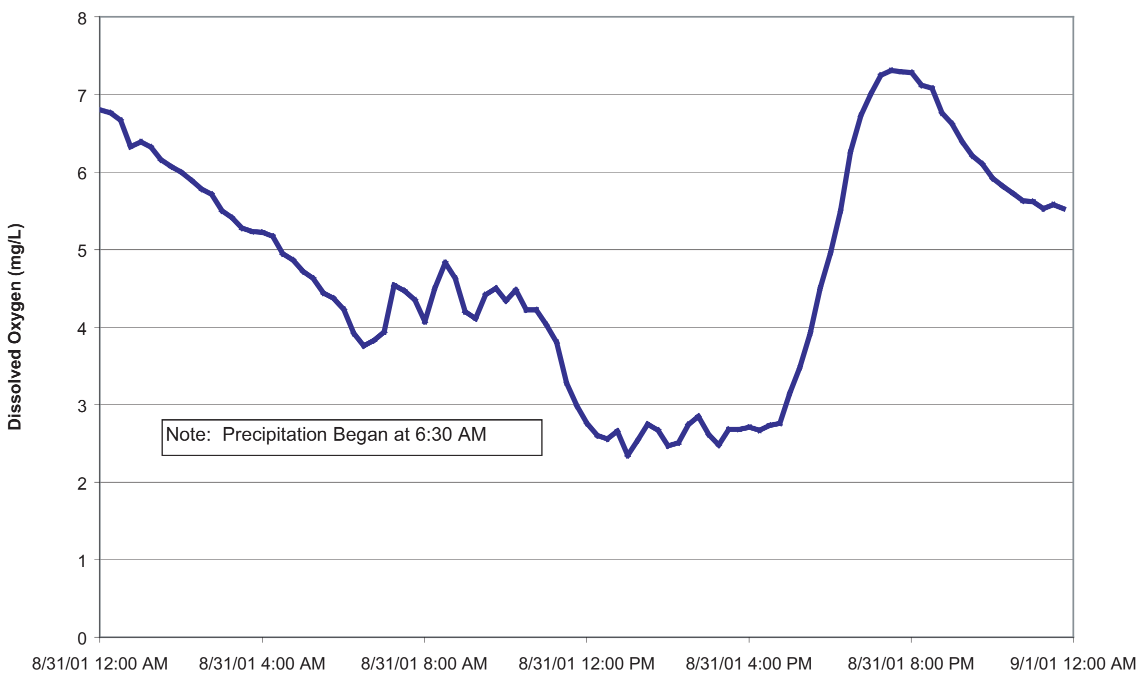

Figure 2-42
Fall Creek Measured Dissolved Oxygen at Boulevard Station
8/31/01 Storm Event

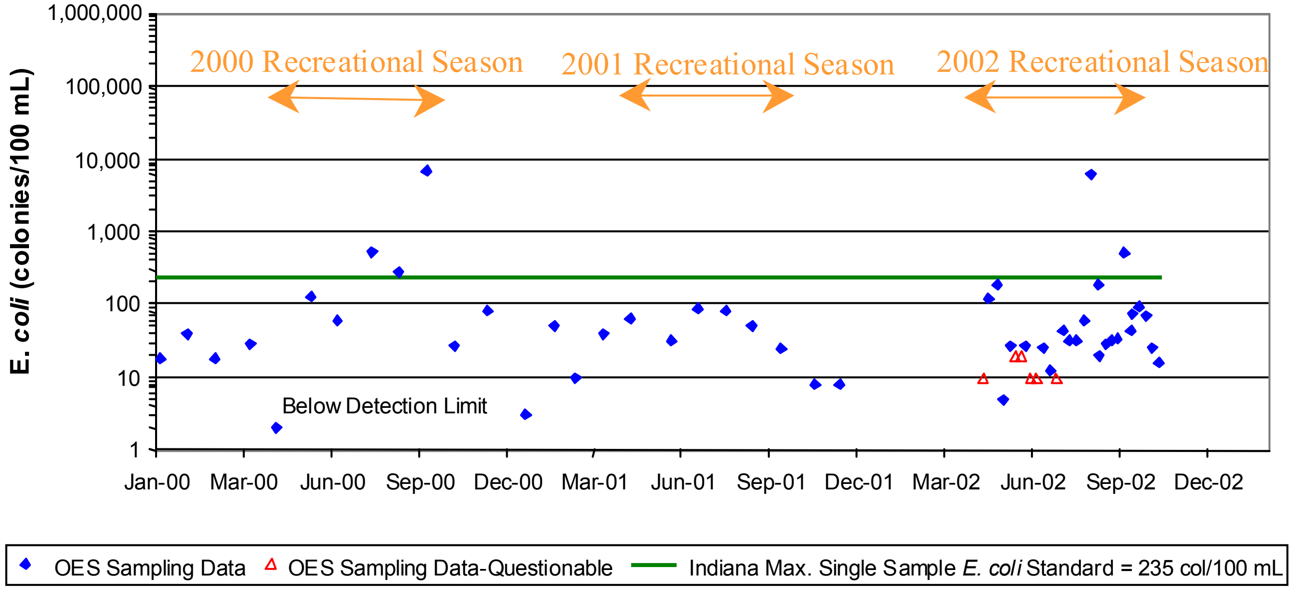

Figure 2-43
Fall Creek *E. coli* Data: 71st Street
City of Indianapolis OES Sampling Sites (January 2000 to October 2002)

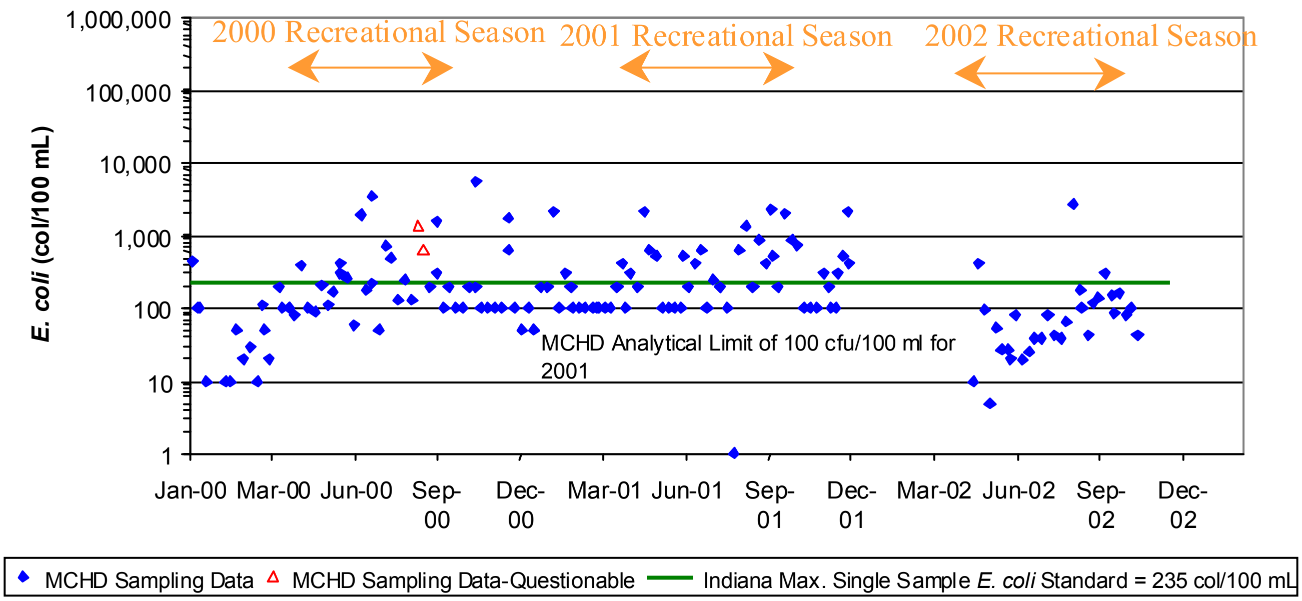

Figure 2-44
Fall Creek *E. coli* Data: Emerson Way
Marion County Health Department Sampling Sites (January 2000 to October 2002)

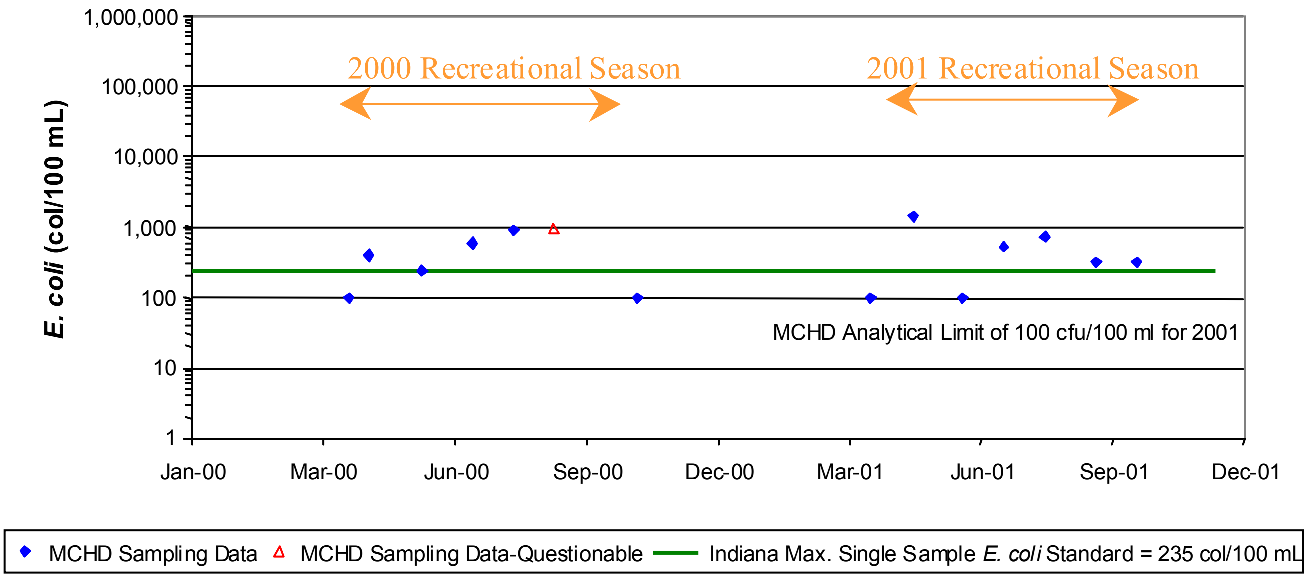

Figure 2-45
Fall Creek *E. coli* Data: 5700 Fall Creek Parkway
Marion County Health Department Sampling Sites (January 2000 to October 2001)

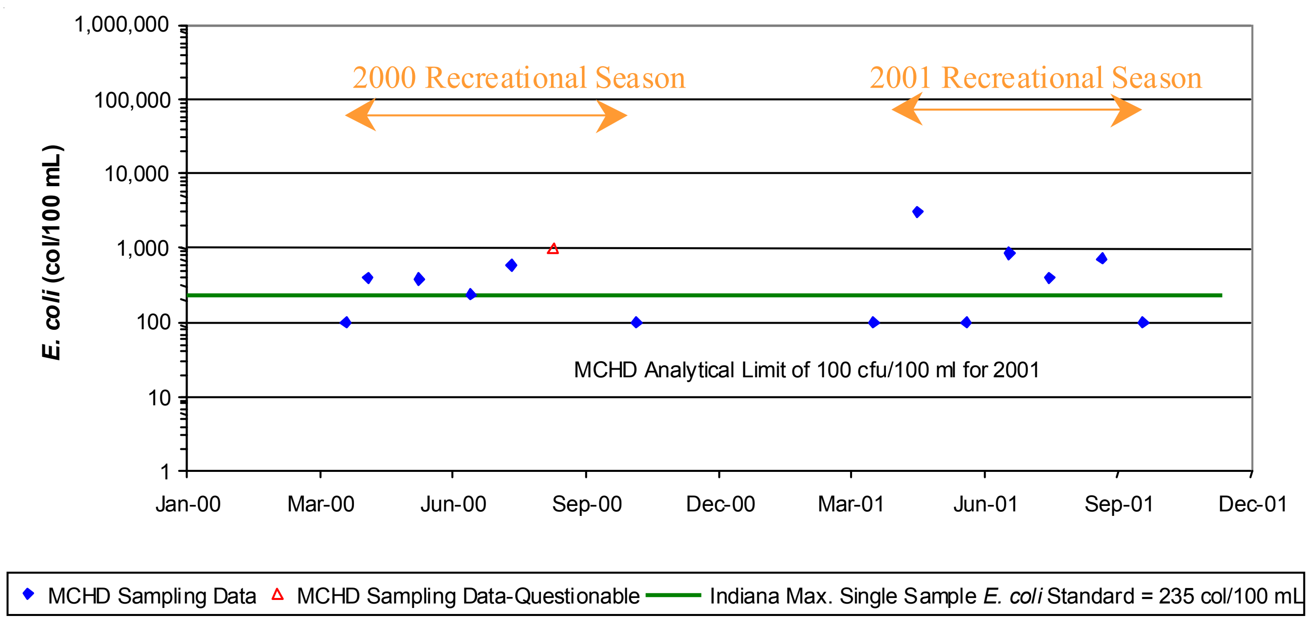

Figure 2-46
Fall Creek *E. coli* Data: 4500 Fall Creek Parkway
Marion County Health Department Sampling Sites (January 2000 to October 2001)

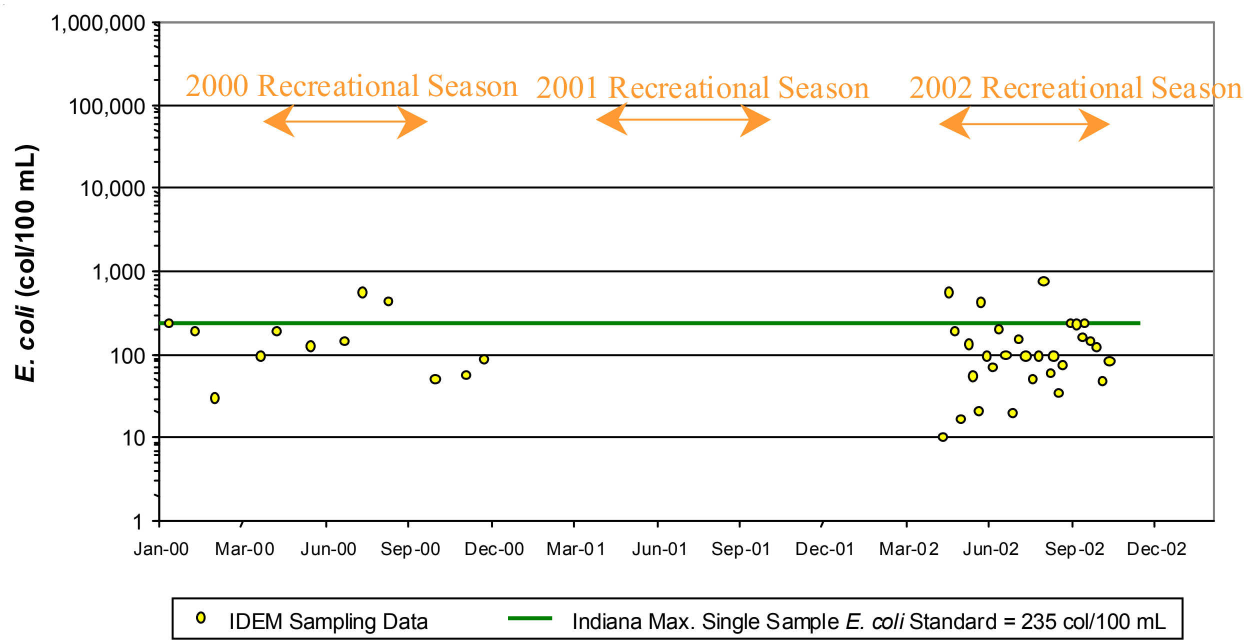

Figure 2-47
Fall Creek *E. coli* Data: Keystone Avenue
Marion County Health Department Sampling Sites (January 2000 to October 2002)

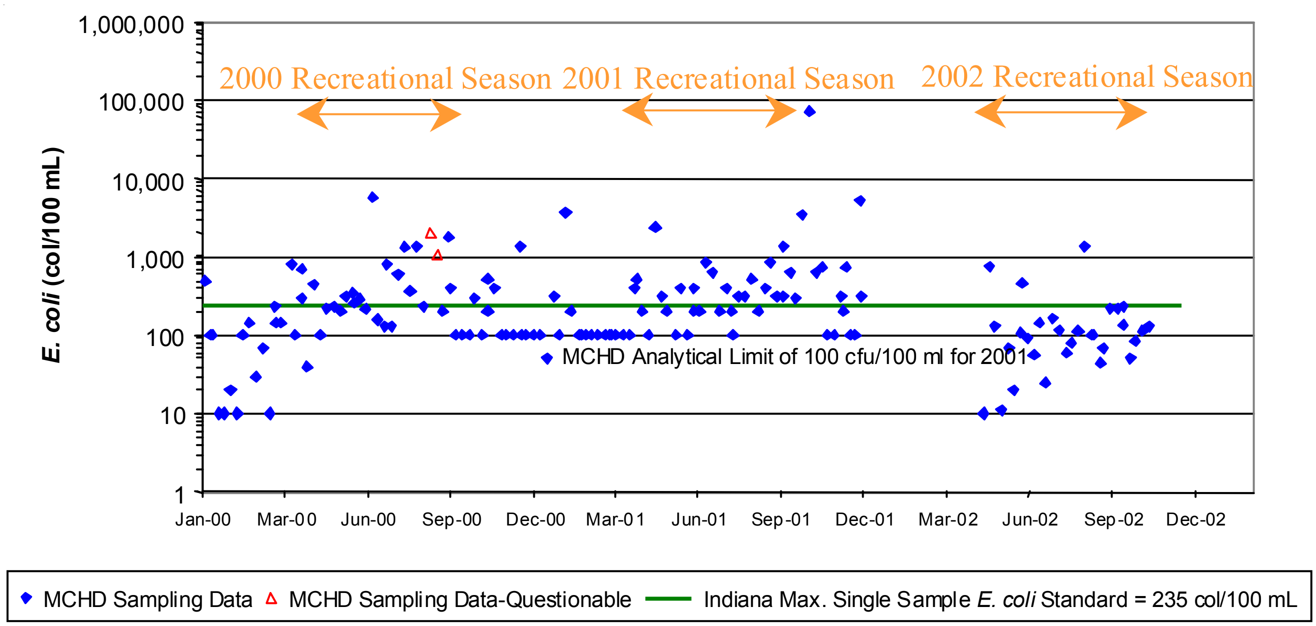

Figure 2-48
Fall Creek *E. coli* Data: 38th Street
Marion County Health Department Sampling Sites (January 2000 to October 2002)

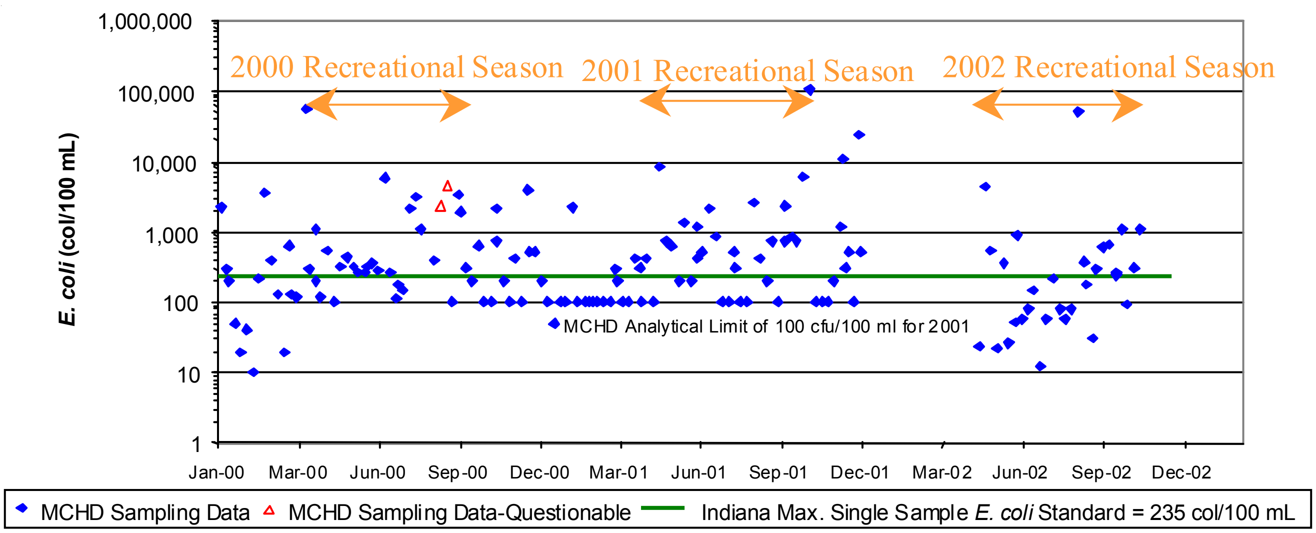

Figure 2-49
Fall Creek *E. coli* Data: 30th Street
Marion County Health Department Sampling Sites (January 2000 to October 2002)

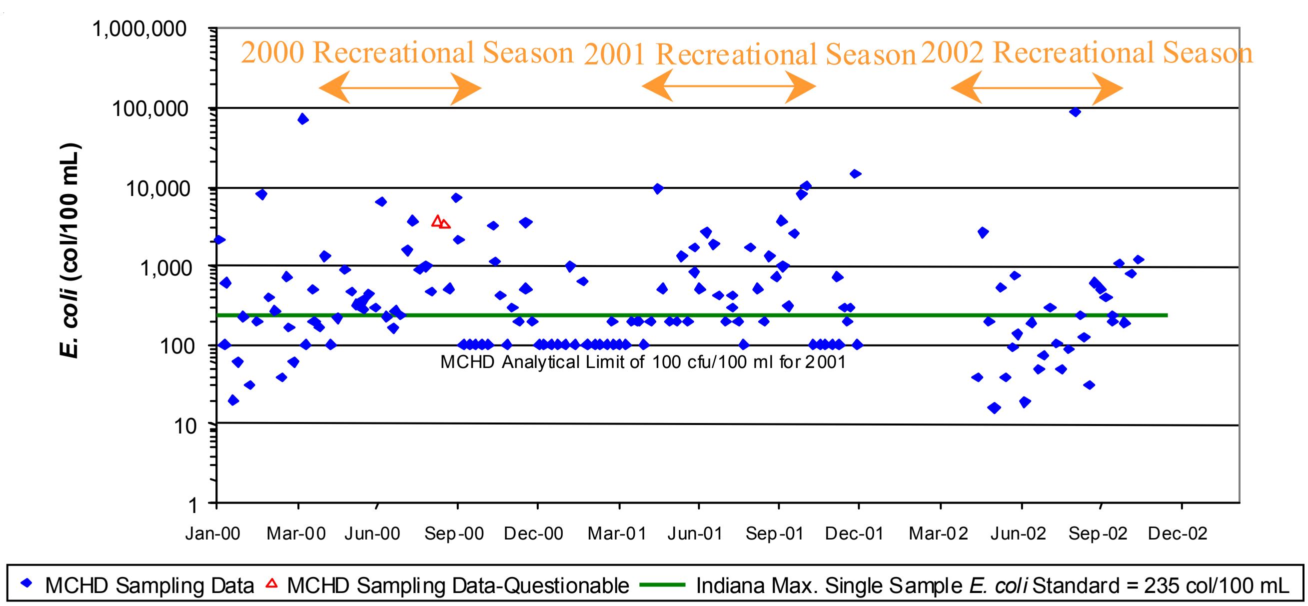

Figure 2-50
Fall Creek *E. coli* Data: Central Avenue
Marion County Health Department Sampling Sites (January 2000 to October 2002)

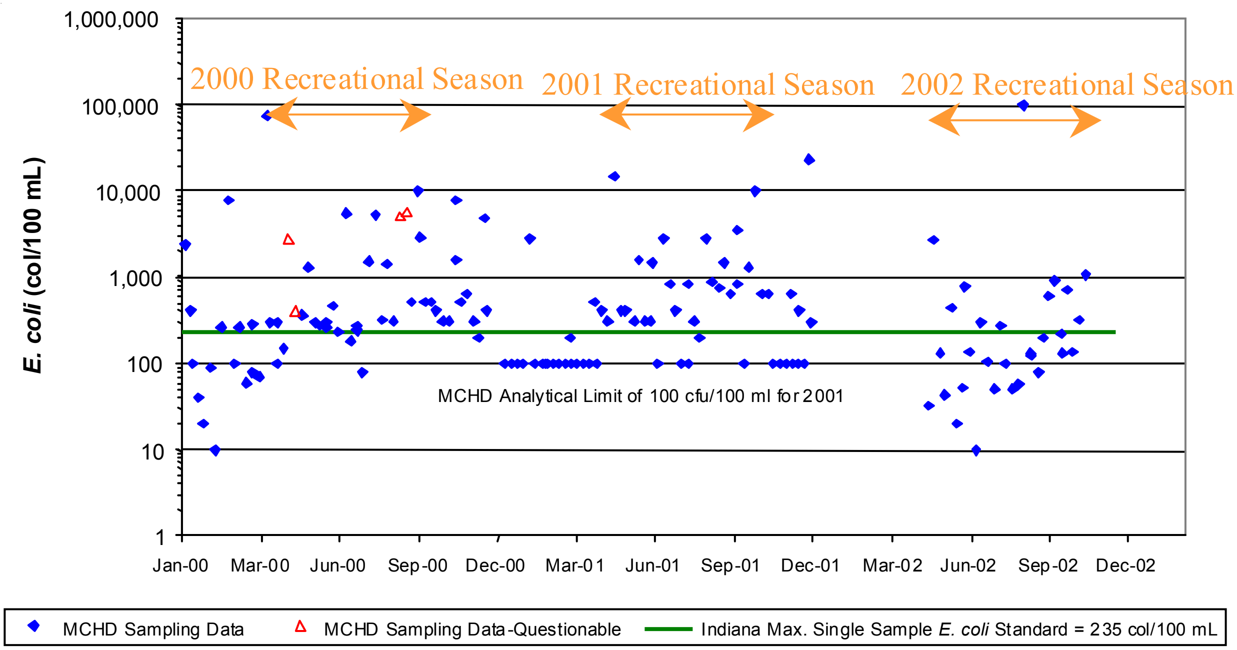

Figure 2-51
Fall Creek *E. coli* Data: Capitol Avenue
Marion County Health Department Sampling Sites (January 2000 to October 2002)

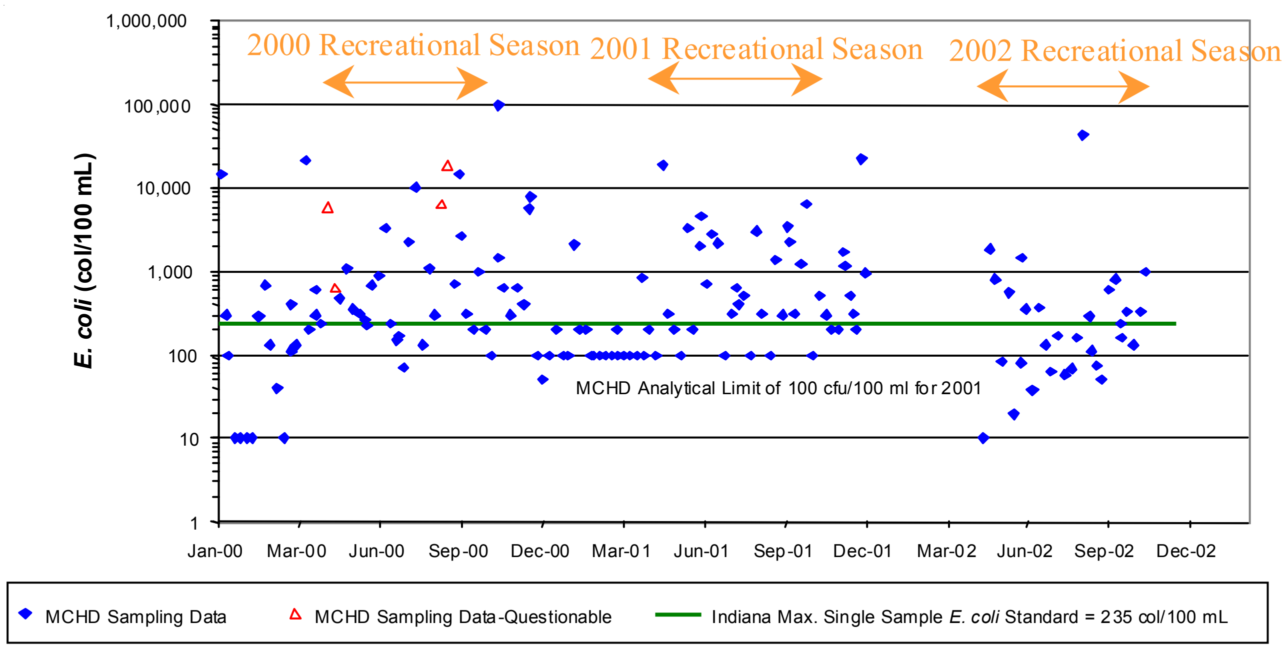

Figure 2-52
Fall Creek *E. coli* Data: Martin Luther King, Jr. Street
Marion County Health Department Sampling Sites (January 2000 to October 2002)

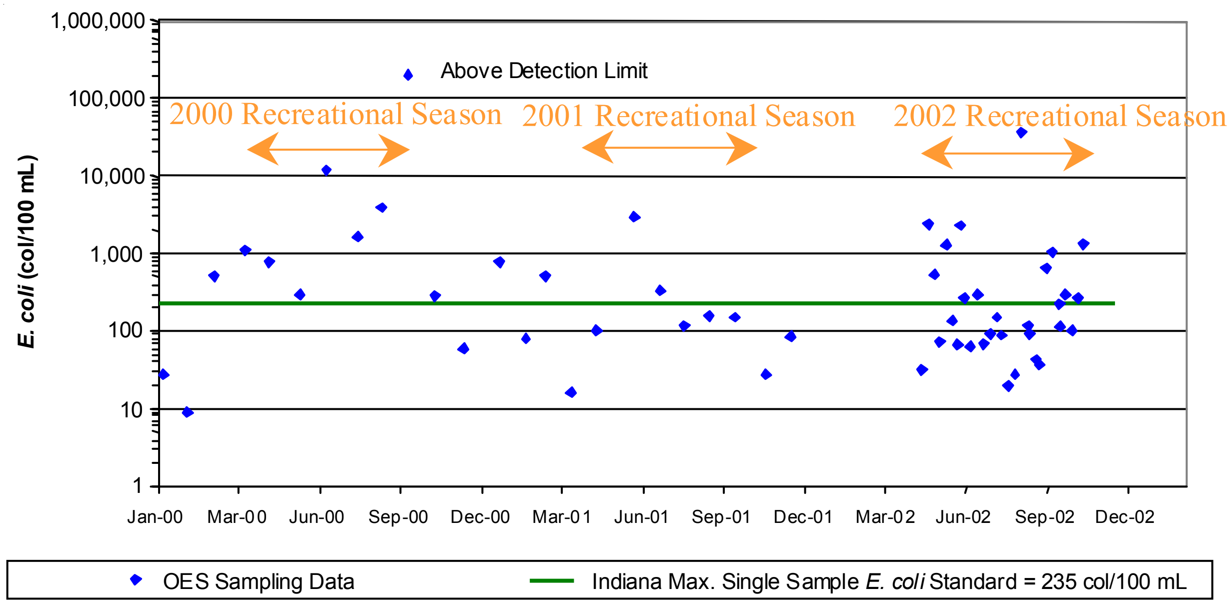

Figure 2-53
Fall Creek *E. coli* Data: 16th Street
Marion County Health Department Sampling Sites (January 2000 to October 2002)

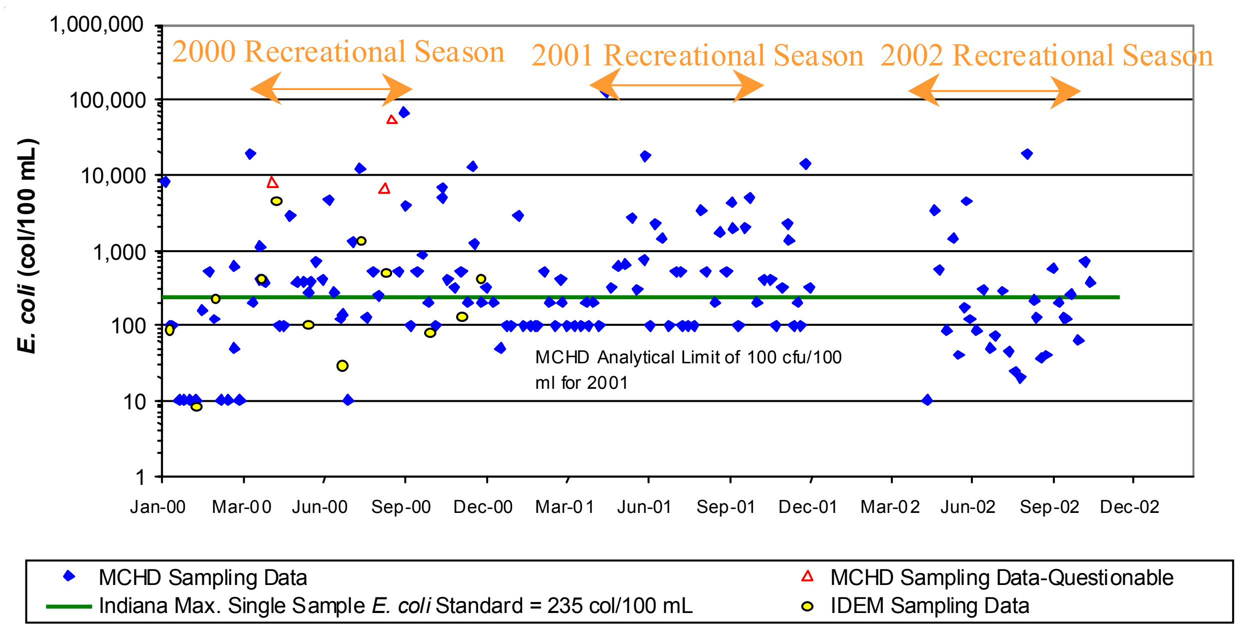

Figure 2-54
Fall Creek *E. coli* Data: Stadium Drive
Marion County Health Department Sampling Sites (January 2000 to October 2002)

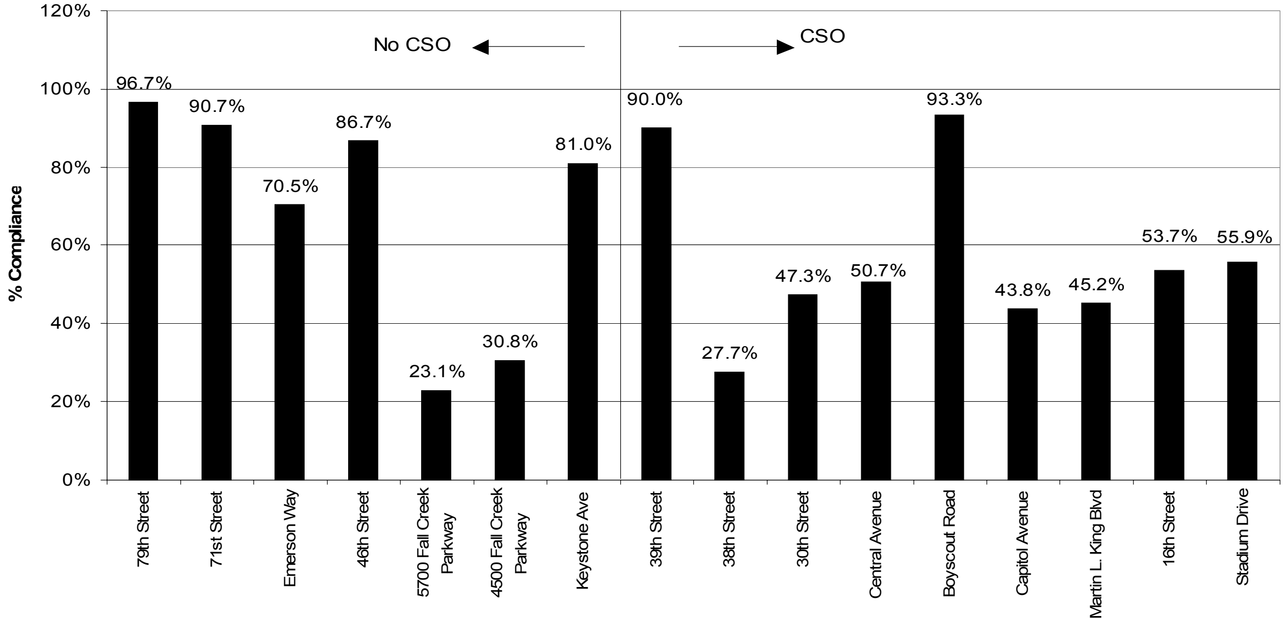

Figure 2-55
Percent Compliance with Indiana Single Sample Maximum *E. coli* Bacteria Standard of 235 cfu/100 ml in Fall Creek April through October for 2000, 2001, and 2002

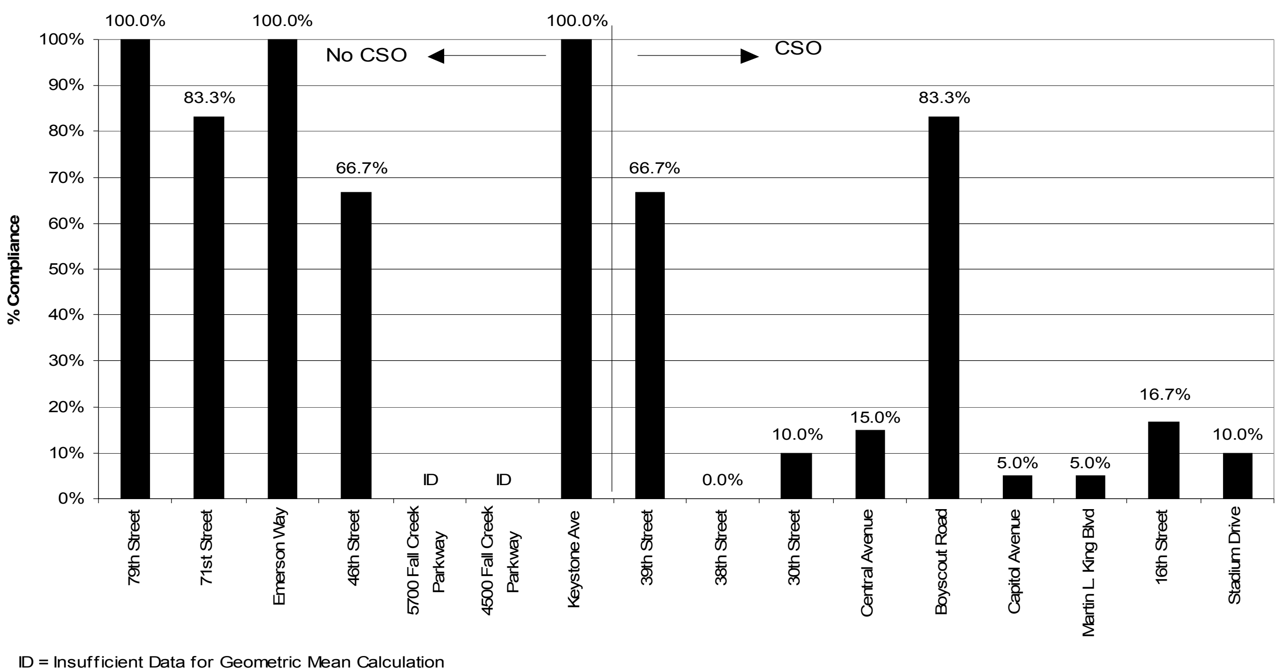

Figure 2-56
Percent Compliance with Indiana Monthly Geometric Mean *E. coli* Bacteria Standard in Fall Creek April through October 2000, 2001, and 2002

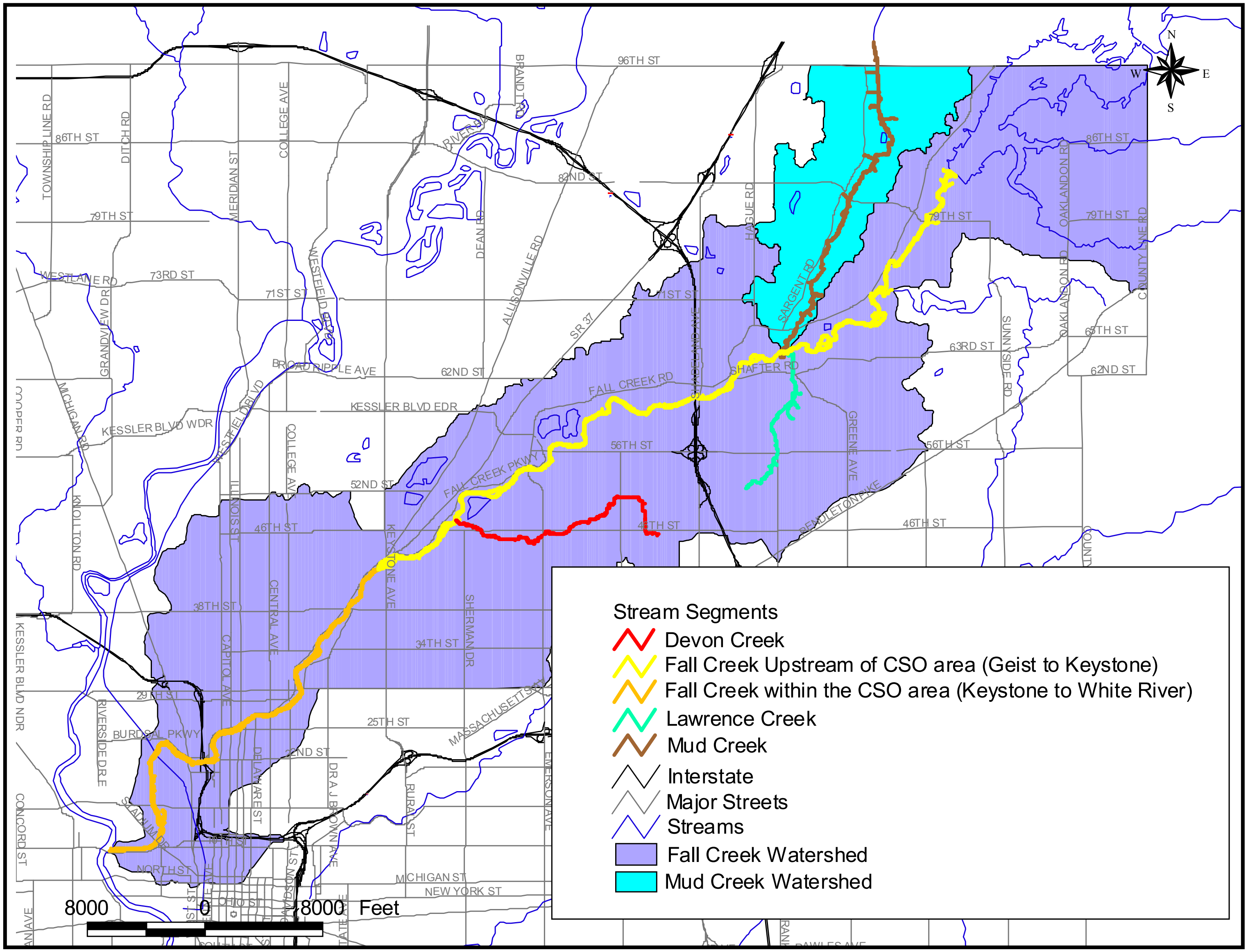

Figure 2-57
Fall Creek Stream Segments

Table 2-3
Fall Creek and Tributaries *E. coli* Bacteria Compliance

All Data

River Segment	Geometric Mean of 2000 2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Fall Creek - Upstream of CSO Area	117	27.4%	0	274
Fall Creek - Within CSO Area	295	50.1%	30	902
Mud Creek - Tributary to Fall Creek	125	16.0%	1	144
Devon Creek - Tributary to Fall Creek	347	59.2%	0	49
Lawrence Creek - Tributary to Fall Creek	132	17.2%	0	29

Dry Weather

River Segment	Geometric Mean of 2000 2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Fall Creek - Upstream of CSO Area	72	11.4%	0	132
Fall Creek - Within CSO Area	146	33.2%	0	425
Mud Creek - Tributary to Fall Creek	89	6.8%	0	73
Devon Creek - Tributary to Fall Creek	259	58.3%	0	24
Lawrence Creek - Tributary to Fall Creek	112	14.3%	0	14

Wet Weather

River Segment	Geometric Mean of 2000 2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Fall Creek - Upstream of CSO Area	185	42.3%	0	142
Fall Creek - Within CSO Area	552	65.2%	30	477
Mud Creek - Tributary to Fall Creek	176	25.4%	1	71
Devon Creek - Tributary to Fall Creek	460	60.0%	0	25
Lawrence Creek - Tributary to Fall Creek	155	20.0%	0	15
State Guidance [1]	**(IDEM standard of 125 cfu/100 ml)**	**(IDEM Guidance 10% or less)**	**(IDEM Guidance None > 10,000 cfu/100 ml)**	

[1] **Indiana's 303(d) Listing Methodology for Impaired Waterbodies and Total Maximum Daily Load - September 2002**

2.4.3.2.2 Dry-Weather Analysis

One stream segment, Mud Creek, is in compliance with all three TMDL *E. coli* bacteria criteria during dry weather. The analysis suggests that the septic and wildlife *E. coli* bacteria loads to Mud Creek are reasonable for the dry-weather baseflow. Two other stream segments, Fall Creek upstream of the CSO area and Lawrence Creek (upstream of the CSO area), are in compliance with the geometric mean standard of 125 cfu/100 mL, but not the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL. The analysis suggests that although the streams possess sufficient baseflow to absorb the *E. coli* bacteria load during a "typical" dry-weather day, frequent low-flow conditions or fluctuations in the septic or wildlife loads occur more than 10 percent of the time during dry weather. Two stream segments, Fall Creek within the CSO area and Devon Creek, do not meet the Indiana geometric mean standard of 125 cfu/100 mL or the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL. The analysis suggests that the septic, illicit connection and wildlife loadings are excessive for the stream.

2.4.3.2.3 Wet-Weather Analysis

All five sampling sites do not meet the Indiana geometric mean standard of 125 cfu/100 mL or the TMDL criteria of less than 10 percent of samples greater than 235 cfu/100 mL. The analysis suggests that each stream segment receives excessive *E. coli* bacteria loadings from stormwater and related sources. The observed wet-weather geometric mean and the 30 samples in excess of 10,000 cfu/100 mL in the Fall Creek CSO area segment in an eighteen-month period imply that CSOs are a dominant source of *E. coli* bacteria in the watershed.

2.4.4 Eagle Creek

2.4.4.1 Dissolved Oxygen

Dissolved oxygen (DO) data was collected at six locations on Little Eagle Creek and Big Eagle Creek at varying intervals from monthly to weekly from January 2000 to May 2002. The data for all six stations showed 100 percent compliance with the Indiana minimum DO standard of 4 mg/L, as shown in **Figures 2-58 and 2-59**.

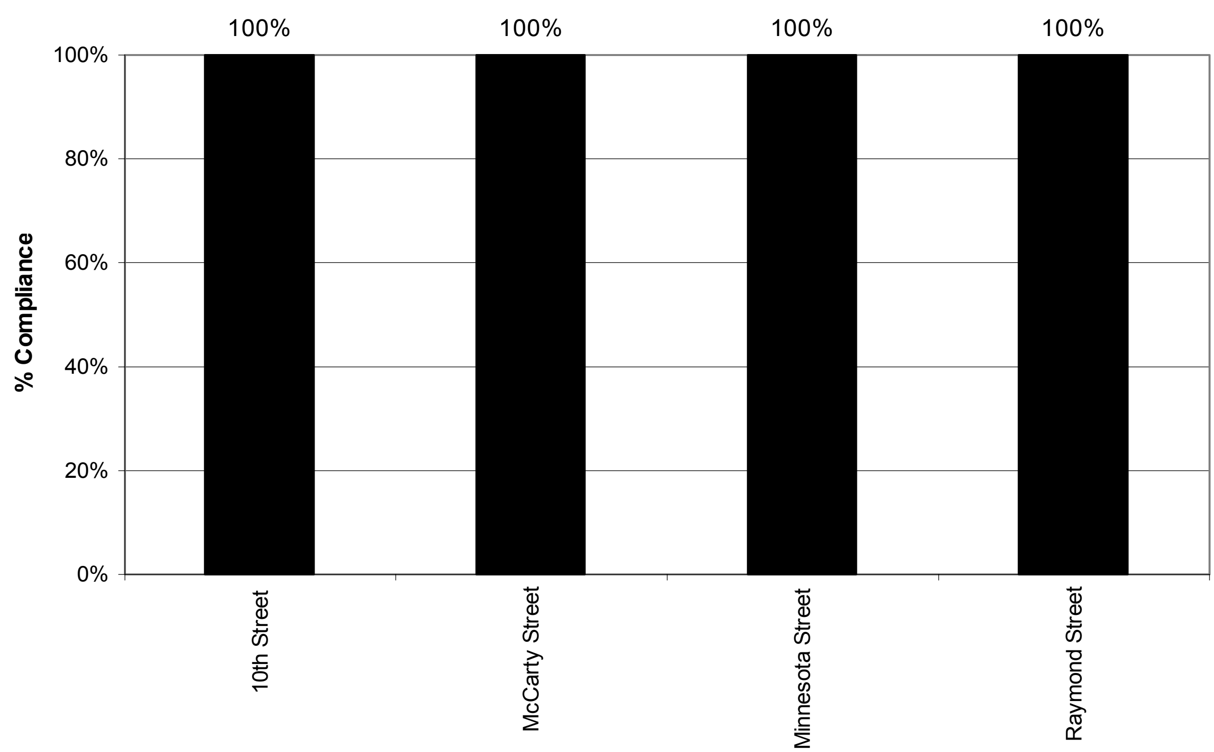

Figure 2-58
Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L in Eagle Creek

2.4.4.2 *E. coli* Bacteria

Data collected between January 2000 and December 2002 demonstrate that Eagle Creek exceeds the Indiana water quality standard for *E. coli* bacteria.

- More than 40 percent of the sampling stations exceeded the daily maximum *E. coli* bacteria standard (235 cfu/100 mL) more than 50 percent of the time.
- None of the sampling stations along Eagle Creek collect sufficient data (five samples in 30 days) to determine the frequency of geometric mean *E. coli* bacteria standard (125 cfu/100 mL) exceedances.

Eagle Creek was divided into two stream segments for analysis purposes:

- Eagle Creek Upstream of the CSO Area: Reservoir to Tibbs Avenue (Big Eagle Creek), 65th Street to Michigan Street (Little Eagle Creek)
- Eagle Creek Within the CSO Area: Tibbs Avenue to the White River (Big Eagle Creek), Michigan Street to the confluence with Big Eagle Creek at Washington Street (Little Eagle Creek)

In-stream *E. coli* bacteria sampling data were grouped for each segment. **Figure 2-60** shows the extent of each stream segment for Eagle Creek.

The findings of the city's compliance analysis are presented in **Table 2-4** for the two Eagle Creek stream segments, based upon all weather, dry-weather, and wet-weather data.

2.4.4.2.1 All-Weather Analysis

Eagle Creek upstream of the CSO area has geometric mean values lower than the Indiana geometric mean standard of 125 cfu/100 mL. However, the stream segment does not meet the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and had one observed count over 10,000 cfu/100 mL. The analysis suggests that Eagle Creek upstream of the CSO area possesses sufficient baseflow to absorb the *E. coli* bacteria load on a "typical" day, but receives excessive *E. coli* loadings from stormwater, illicit connections and septic sources during wet weather or low-flow, dry-weather days. In the CSO area, Eagle Creek exceeds the the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples

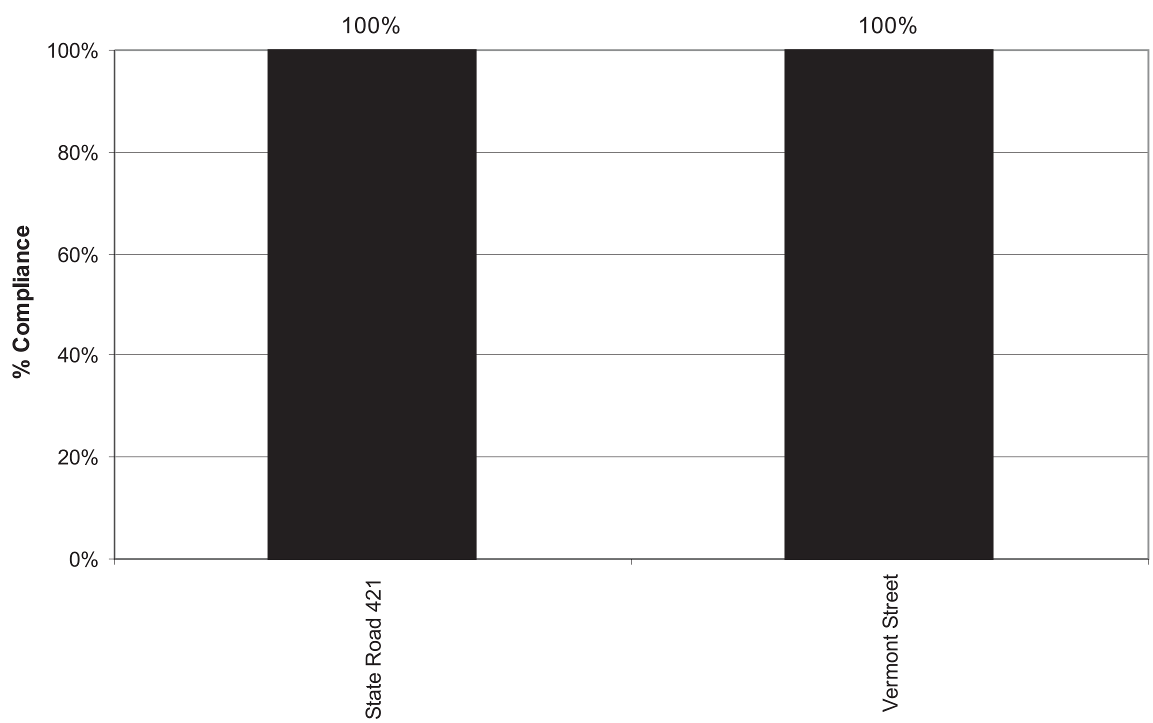

Figure 2-59
Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L in Little Eagle Creek

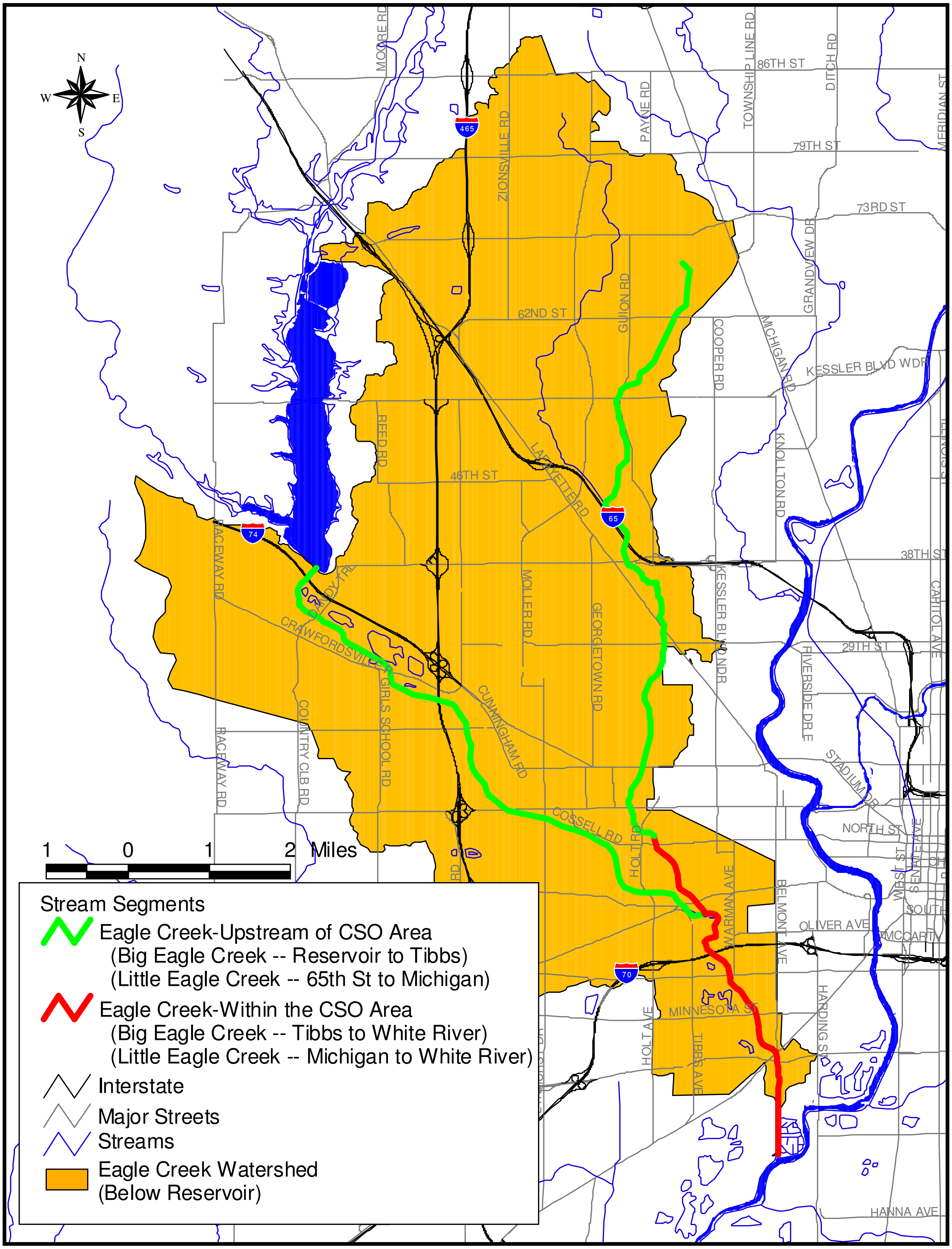

Figure 2-60
Eagle Creek Stream Segments

Table 2-4
Eagle Creek *E. coli* Bacteria Compliance

River Segment	Geometric Mean of 2000-2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
All Data				
Eagle Creek - Upstream of CSO Area	70	14.3%	1	21
Eagle Creek - Within CSO Area	419	58.7%	2	63
Dry Weather				
Eagle Creek - Upstream of CSO Area	49	7.1%	0	14
Eagle Creek - Within CSO Area	165	44.7%	0	38
Wet Weather				
Eagle Creek - Upstream of CSO Area	145	28.6%	1	7
Eagle Creek - Within CSO Area	1719	80.0%	2	25
State Guidance (1)	(IDEM standard of 125 cfu/100 ml)	(IDEM Guidance 10% or less)	(IDEM Guidance None > 10,000 cfu/100 ml)	

(1) Indiana's 303(d) Listing Methodology for Impaired Waterbodies and Total Maximum Daily Load - September 2002

above 10,000 cfu/100 mL. The analysis suggests that CSOs are a significant source of *E. coli* bacteria in the stream. Another potential source of *E. coli* in Eagle Creek is the Town of Speedway's wastewater treatment plant and its primary effluent bypass.

2.4.4.2.2 Dry-Weather Analysis

During dry-weather conditions, the upstream segment of Eagle Creek is in compliance with the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples above 10,000 cfu/100 mL. The analysis suggests that Eagle Creek contains sufficient baseflow to absorb the *E. coli* bacteria load during dry-weather conditions. However, in the CSO area, Eagle Creek is does not meet the Indiana geometric mean standard of 125 cfu/100 mL, and the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL. The analysis suggests that the septic, pets/wildlife, and illicit connection loads are excessive for the stream as it becomes more urbanized.

2.4.4.2.3 Wet-Weather Analysis

During wet-weather conditions, neither stream segment of Eagle Creek meets the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples above 10,000 cfu/100 mL. The analysis suggests that stormwater and CSOs are a significant source of *E. coli* bacteria to the stream. The substantial difference in geometric means between the CSO area and upstream segments in Eagle Creek suggest that CSOs are a significant source of *E. coli* bacteria to the stream.

2.4.5 Pleasant Run and Bean Creek

2.4.5.1 Dissolved Oxygen

Dissolved oxygen (DO) data was collected at 10 locations on Pleasant Run and Bean Creek at varying intervals from monthly to weekly from January 2000 to May 2002. The data for five stations out of the 10 showed 100 percent compliance with the Indiana DO standard of 4 mg/L. The exceptions were located at 21st Street, Southeastern Avenue, Garfield Park, and Bluff Road on Pleasant Run, and Keystone Avenue on Bean Creek. **Figures 2-61** and **2-62** present this information. An analysis of the data indicates the low dissolved oxygen concentrations occur primarily with low streamflows. The dissolved oxygen concentration generally improves with wet weather or higher streamflows. This suggests that the DO issues in Pleasant Run and Bean Creek are not caused by CSOs.

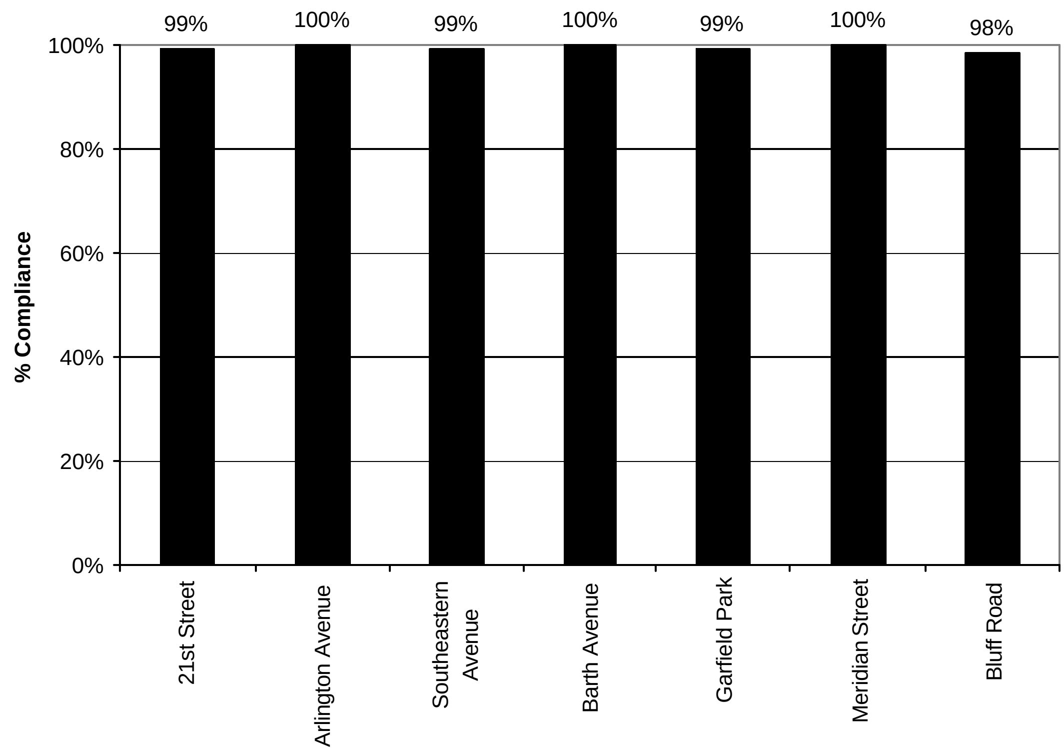

Figure 2-61
Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L in Pleasant Run

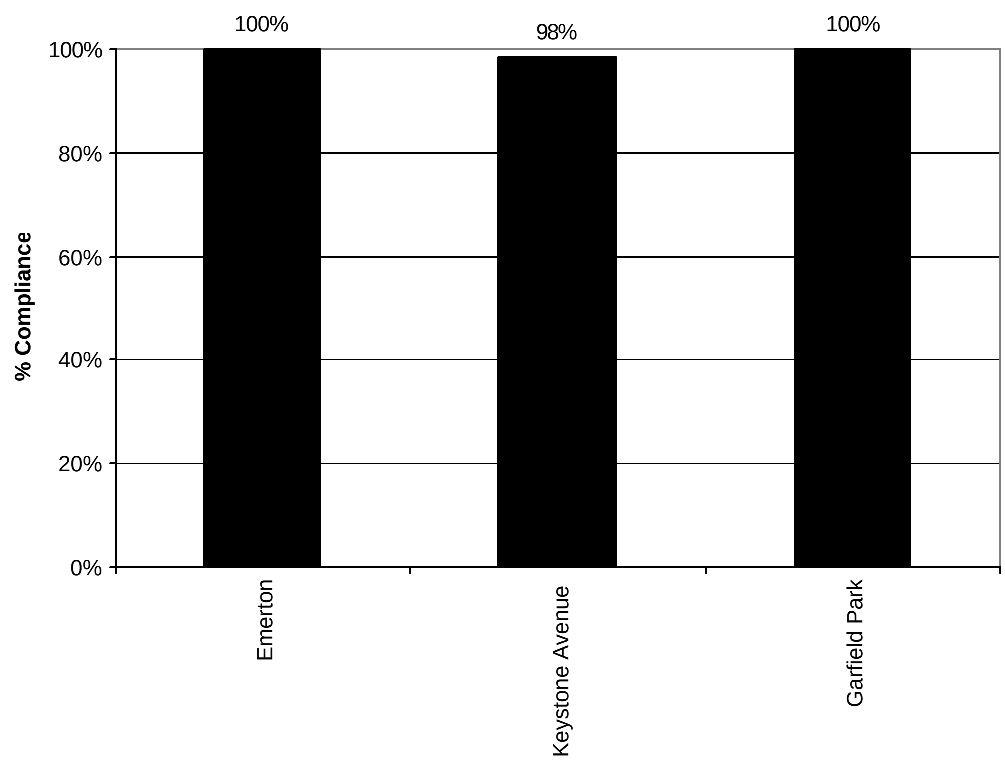

Figure 2-62
Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L in Bean Creek

2.4.5.2 *E. coli* Bacteria

Available data from 2000-2002 were compared to both the maximum monthly *E. coli* bacteria standard of 235 cfu/100 mL and the monthly geometric mean standard of 125 cfu/100 mL.

Overall, the major findings are:

- More than 90 percent of the sampling stations exceed the daily maximum *E. coli* bacteria standard (235 cfu/100mL) more than 50 percent of the time.
- All of the sampling stations with sufficient data to calculate the geometric mean (five samples in 30 days) exceed the geometric mean *E. coli* bacteria standard (125 cfu/100 mL) 100 percent of the time.

From 21st Street to the confluence with the White River, Pleasant Run exhibits often does not meet the *E. coli* single sample maximum bacteria standard. In addition, the number of exceedances of the standard occurring upstream of the CSO segment is similar to the number of exceedances occurring within the CSO stream segment.

Pleasant Run and Bean Creek were divided into the following segments for analysis purposes:

- Pleasant Run Upstream of the CSO Area: (30th Street to 9th Street)
- Pleasant Run Within the CSO Area: (9th Street to the confluence with the West Fork of the White River)
- Bean Creek Upstream of the CSO Area: (Arlington Avenue to State Street)
- Bean Creek Within the CSO Area: (State Street to confluence with Pleasant Run)

Figure 2-63 shows the extent of each stream segment analyzed. **Table 2-5** summarizes *E. coli* bacteria samples for each stream segment compared to the three TMDL *E. coli* bacteria compliance criteria. Findings are presented for dry weather, wet weather, and all weather.

2.4.5.2.1 All-Weather Analysis

All four stream segments do not meet the *E. coli* bacteria monthly geometric mean standard of 125 cfu/100 mL or the TMDL criteria of less than 10 percent of samples below 235

Table 2-5
Pleasant Run and Bean Creek *E. coli* Bacteria Compliance

River Segment	Geometric Mean of 2000-2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Pleasant Run - Upstream of CSO Area	342	59.3%	4	258
Pleasant Run - Within CSO Area	413	59.5%	29	862
Bean Creek - Upstream of CSO Area	502	71.1%	8	340
Bean Creek - Within CSO Area	466	71.3%	5	178

Dry Weather

River Segment	Geometric Mean of 2000-2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Pleasant Run - Upstream of CSO Area	267	56.2%	0	137
Pleasant Run - Within CSO Area	269	53.8%	3	461
Bean Creek - Upstream of CSO Area	421	68.6%	1	175
Bean Creek - Within CSO Area	346	70.5%	0	88

Wet Weather

River Segment	Geometric Mean of 2000-2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Pleasant Run - Upstream of CSO Area	454	62.8%	4	121
Pleasant Run - Within CSO Area	676	66.1%	26	401
Bean Creek - Upstream of CSO Area	603	73.3%	7	165
Bean Creek - Within CSO Area	625	72.2%	5	90
State Guidance [(1)]	(IDEM standard of 125 cfu/100 ml)	(IDEM Guidance 10% or less)	(IDEM Guidance None > 10,000 cfu/100 ml)	

[(1)] Indiana's 303(d) Listing Methodology for Impaired Waterbodies and Total Maximum Daily Load - September 2002

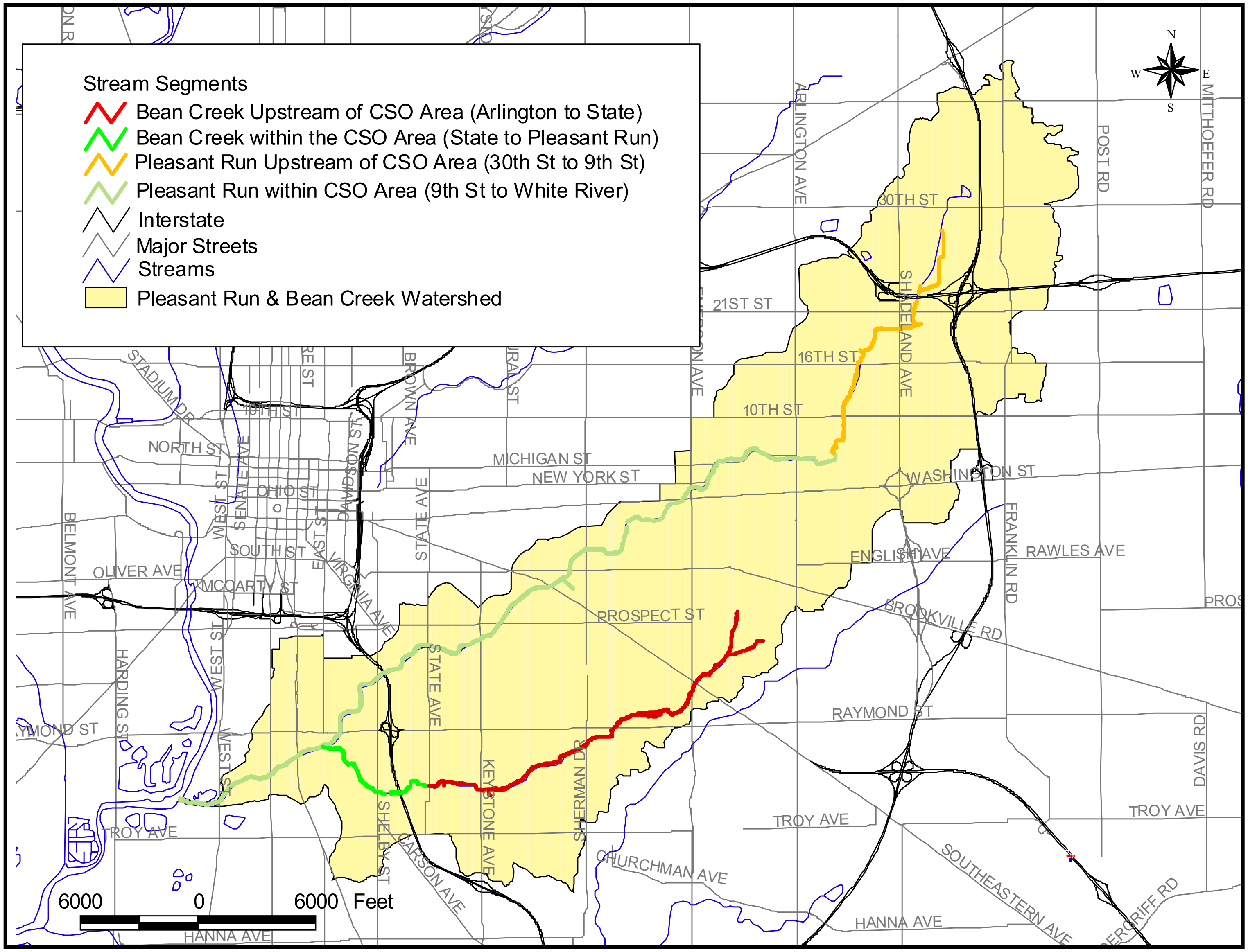

Figure 2-63
Pleasant Run and Bean Creek Stream Segments

cfu/100 mL and no samples in excess of 10,000 cfu/100 mL. The analysis suggests that all stream segments are not able to accept the *E. coli* bacteria load from septic, stormwater, and CSO sources. The 29 samples in excess of 10,000 cfu/100 mL in the Pleasant Run CSO area imply that CSOs are a significant source of *E. coli* bacteria to the stream. The high number of samples in excess of 10,000 cfu/100 mL in Bean Creek upstream of the CSO area suggests that pets/wildlife, septic and stormwater sources are significant to that stream segment.

2.4.5.2.2 Dry-Weather Analysis

All four stream segments do not meet the Indiana geometric mean standard of 125 cfu/100 mL or the TMDL criteria of less than 10 percent of samples above 235 cfu/100 mL during dry weather. The analysis suggests that the septic, wildlife, and illicit connection loads are excessive for the stream. The presence of samples in excess of 10,000 cfu/100 mL in Bean Creek and the Pleasant Run CSO area segment illustrates the significance of these dry-weather sources.

2.4.5.2.3 Wet-Weather Analysis

All four stream segments fail to comply with all three criteria during wet weather. The analysis suggests that the septic, stormwater and CSO loads are excessive for the stream. However, there is a relatively small difference between dry-weather and wet-weather periods in the percent of samples above 235 cfu/100 mL. This comparison and the geometric mean values ranging from 267 - 421 in dry weather suggest that dry-weather loads are producing *E. coli* bacteria concentrations in slight excess of 235 cfu/100 mL, while wet-weather loads are producing *E. coli* bacteria concentrations far in excess of 235 cfu/100 mL.

2.4.6 Pogues Run

2.4.6.1 Dissolved Oxygen

Dissolved oxygen (DO) data was collected at six locations on Pogues Run at varying intervals from monthly to weekly from January 2000 to May 2002. The data for two stations out of the six showed 100 percent compliance with the Indiana DO standard of 4 mg/L minimum. The exceptions were located at 38th Street, Emerson Avenue, 21st Street, and at the New York Street Station. **Figure 2-64** presents this information.

An analysis of the data indicates the low dissolved oxygen concentrations occur primarily with low streamflows. The dissolved oxygen concentration generally improves with wet weather or higher streamflows. This suggests that the

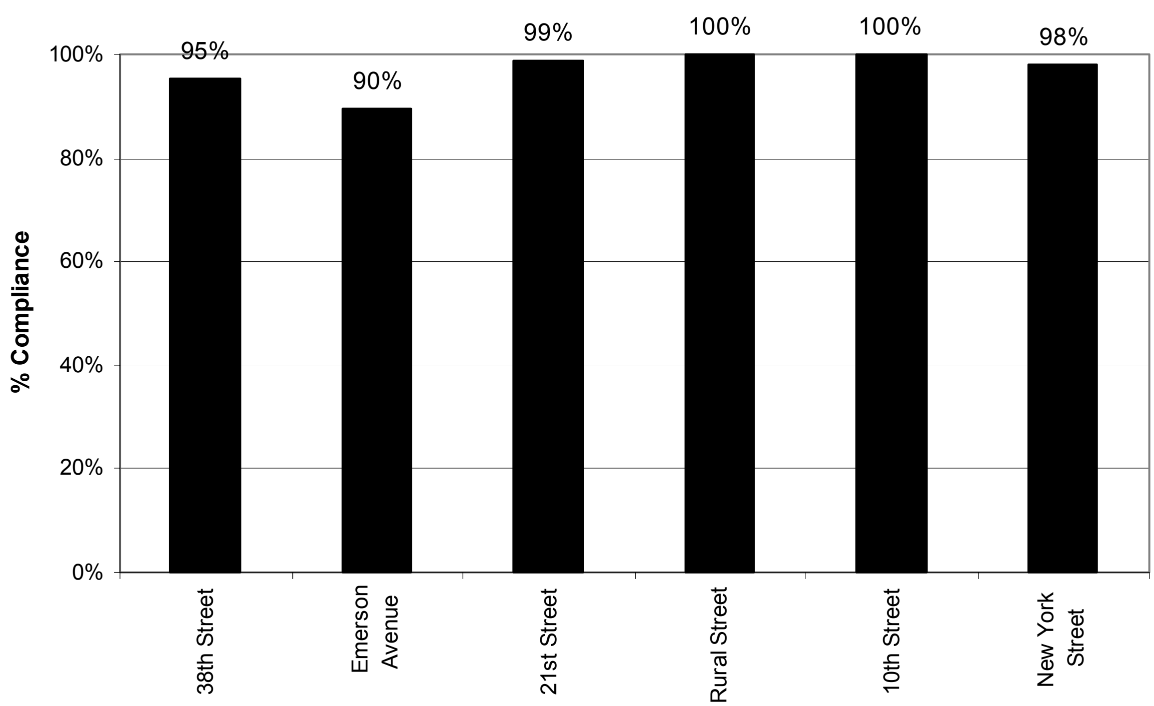

Figure 2-64
Percent Compliance with Indiana Dissolved Oxygen Standard of 4 mg/L in Pogues Run

dissolved oxygen issues in Pleasant Run and Bean Creek are not caused by CSOs.

2.4.6.2 *E. coli* Bacteria

Data collected between January 2000 and December 2002 demonstrate that Pogues Run exceeds the Indiana water quality standard for *E. coli* bacteria.

- More than 70 percent of the sampling stations exceeded the daily maximum *E. coli* bacteria standard (235 cfu/100 mL) more than 50 percent of the time.
- All of the sampling stations with sufficient data (five samples in 30 days) exceed the geometric mean *E. coli* bacteria standard (125 cfu/100 mL) at least 90 percent of the time.

Pogues Run was divided into two stream segments for analysis purposes:

- Pogues Run Upstream of the CSO Area: Shadeland Ave. to I-70
- Pogues Run Within the CSO Area: I-70 to New York Street

In-stream *E. coli* bacteria sampling data were grouped for each segment. **Figure 2-65** shows the extent of each stream segment for Pogues Run.

The findings of the city's compliance analysis are presented in **Table 2-6** for the two Pogues Run stream segments, based upon all-weather, dry-weather, and wet-weather data.

2.4.6.2.1 All-Weather Analysis

Neither stream segment of Pogues Run meets the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples above 10,000 cfu/100 mL. The analysis suggests that Pogues Run does not possess sufficient baseflow to absorb the *E. coli* bacteria load on a "typical" day, or during wet-weather or low-flow, dry-weather conditions. The analysis suggests that these streams are not able to absorb the *E. coli* bacteria load from wildlife, septic, stormwater, and CSO sources.

2.4.6.2.2 Dry-Weather Analysis

During dry-weather conditions, neither stream segment of Pogues Run is in compliance with the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples above 10,000 cfu/100 mL. The analysis suggests that the septic, pets/wildlife, and illicit connection loads are excessive for the stream. The presence of samples in excess of 10,000 cfu/100 mL illustrates the significance of these dry-weather loads.

Table 2-6
Pogues Run *E. coli* Bacteria Compliance

River Segment	Geometric Mean of 2000-2002 data	% of Samples > 235 cfu/100 ml	Number of Samples > 10,000 cfu/100 ml	Total Number of Samples
Pogues Run - Upstream of CSO Area	896	72.8%	6	228
Pogues Run - Within CSO Area	481	64.9%	9	536
Dry Weather				
River Segment	**Geometric Mean of 2000-2002 data**	**% of Samples > 235 cfu/100 ml**	**Number of Samples > 10,000 cfu/100 ml**	**Total Number of Samples**
Pogues Run - Upstream of CSO Area	634	66.4%	2	107
Pogues Run - Within CSO Area	251	51.3%	2	271
Wet Weather				
River Segment	**Geometric Mean of 2000-2002 data**	**% of Samples > 235 cfu/100 ml**	**Number of Samples > 10,000 cfu/100 ml**	**Total Number of Samples**
Pogues Run - Upstream of CSO Area	1217	78.5%	4	121
Pogues Run - Within CSO Area	934	78.9%	7	265
State Guidance [1]	**(IDEM standard of 125 cfu/100 ml)**	**(IDEM Guidance 10% or less)**	**(IDEM Guidance None > 10,000 cfu/100 ml)**	

[1] Indiana's 303(d) Listing Methodology for Impaired Waterbodies and Total Maximum Daily Load - September 2002

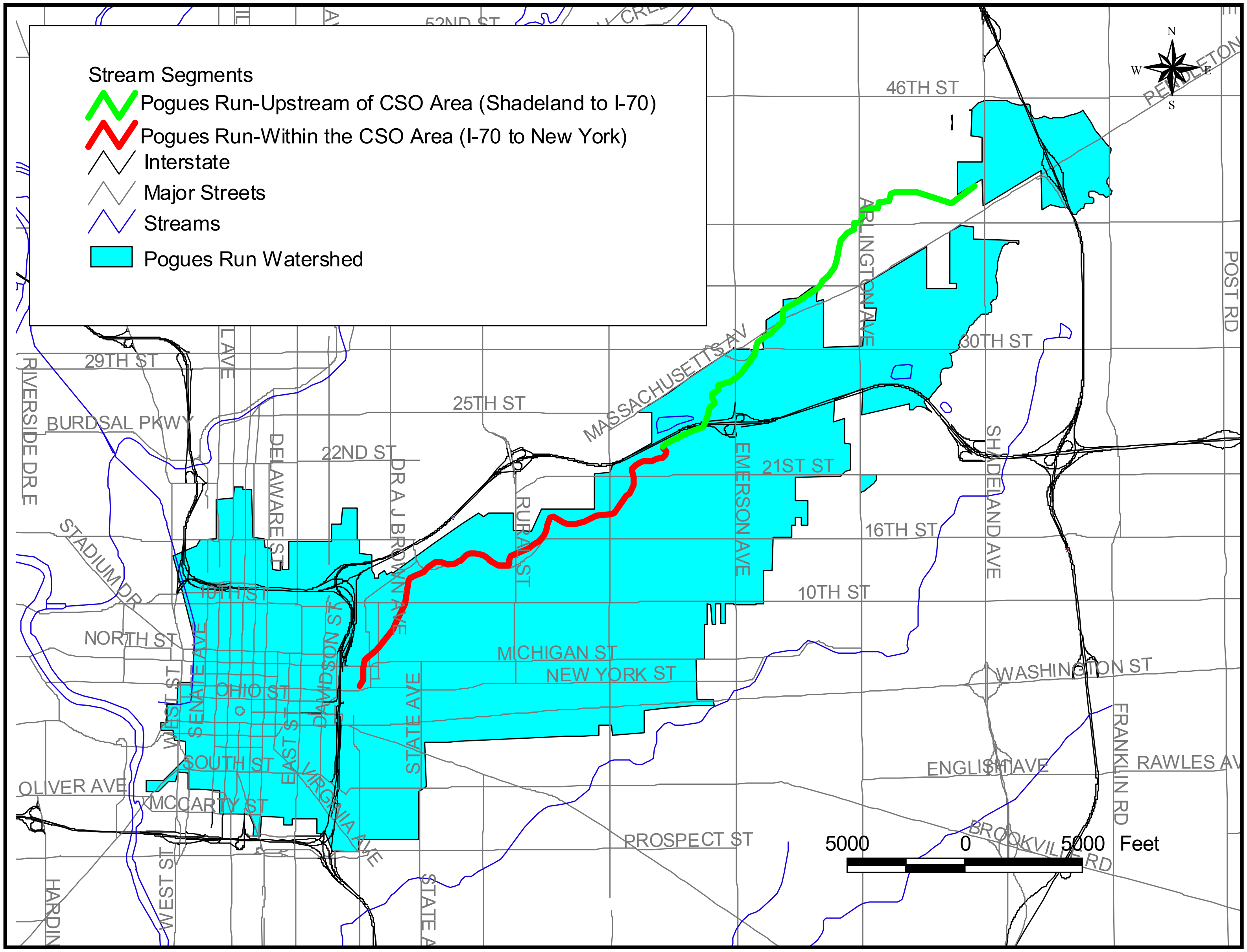

Figure 2-65
Pogues Run Stream Segments

2.4.6.2.3 Wet-Weather Analysis

During wet-weather conditions, neither stream segment of Pogues Run meets the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples above 10,000 cfu/100 mL. The observed wet-weather geometric mean in the upstream segment of Pogues Run suggests that stormwater, illicit connections and septic sources are a significant source of *E. coli* bacteria in the stream.

2.4.7 Lick Creek and State Ditch

State Ditch and Lick Creek are two small urban streams located in southern Marion County, shown in **Figures 2-66** and **2-67**. Both streams have all the problems commonly identified with urban streams: decreased baseflow, elevated peak flows, and polluted runoff. State Ditch was listed by IDEM on the 1998 303(d) list as having three parameters of concern: cyanide, pH and *E. coli*. The 2002 303(d) list notes two parameters of concern for State Ditch: impaired biotic communities and *E. coli*.

Neither State Ditch nor Lick Creek meet the Indiana geometric mean standard of 125 cfu/100 mL, the TMDL criteria of less than 10 percent of samples below 235 cfu/100 mL, and the TMDL criteria of no samples above 10,000 cfu/100 mL. Marion County Health Department data suggest neither State Ditch nor Lick Creek possess sufficient baseflow to absorb the *E. coli* bacteria load on a "typical" day, during wet-weather, or during low-flow, dry-weather conditions. The analysis suggests that these streams are not able to absorb the *E. coli* bacteria load from pets/wildlife, septic, illicit connections, stormwater, and CSO sources.
Sewer separation projects will be implemented for both of these relatively small isolated CSO areas.

2.5 Sewer System Characterization

The City of Indianapolis owns the wastewater collection system serving most of Marion County. Under contract with the city, United Water manages the collection system. Both combined and sanitary sewers carry wastewater to three combined interceptor branches and a centrally located core combined interceptor subnetwork. Additionally, separate sewers carry wastewater to the core interceptor subnetwork and to sanitary interceptors. These interceptors carry wastewater to two advanced wastewater treatment (AWT) facilities, the Belmont and Southport AWT plants.

The combined sewer area, which is located primarily in the older sections of the City of Indianapolis, contains 132 combined sewer outfalls. The following subsections provide a detailed discussion of the combined sewer system. The separate sewer area extends beyond the combined sewer area to the limits of the county. The following subsections also provide a detailed discussion of the separate interceptors. **Figure 2-68** shows the locations and alignment of the city's interceptor network.

2.5.1 Combined Sewer Area

The yellow-shaded area in **Figure 2-68** shows the combined sewer area, which generally follows the pre-1972 city limits, before the city and county governments were consolidated. The map also shows the Belmont and Southport AWT plants. The combined sewer area covers approximately 55.5 square miles.

Combined sewers overflow when the volume of sewage and rainwater exceeds a pipe's carrying capacity. Interceptors are typically smaller than combined sewers and reach capacity much more frequently. Under dry-weather conditions, regulators divert these combined flows into interceptor sewers for conveyance to one of the two treatment facilities. Typically, a regulator consists of a small dam in the sewer pipe that conveys dry-weather sewage flows to the interceptor, but allows high wet-weather overflows to escape into a stream via an outfall pipe. Some CSO outfalls serve more than one regulator.

2.5.2 Combined Sewer System Interceptor Network

Interceptors are underground pipes that carry flows from the sewers to the treatment plant. The city's combined sewer interceptor network has three branches: the Pleasant Run/ Bean Creek, Pogues Run, and Fall Creek interceptor branches. These three interceptor branches flow into a centrally located core interceptor subnetwork, which conveys the sewage into the Belmont and Southport AWT plants.

The core interceptor subnetwork contains 23.4 miles of interceptor sewers, 15 overflow points, 8,337 acres of tributary area, and three pump stations. This subnetwork includes the Belmont, West Indianapolis, Southwest Diversion, White River, and Adler-McCarty interceptors and conveys wastewater from the three combined interceptor branches described above (as well as from the northerly portions of the separate sewer area) to the Belmont and Southport AWT plants.

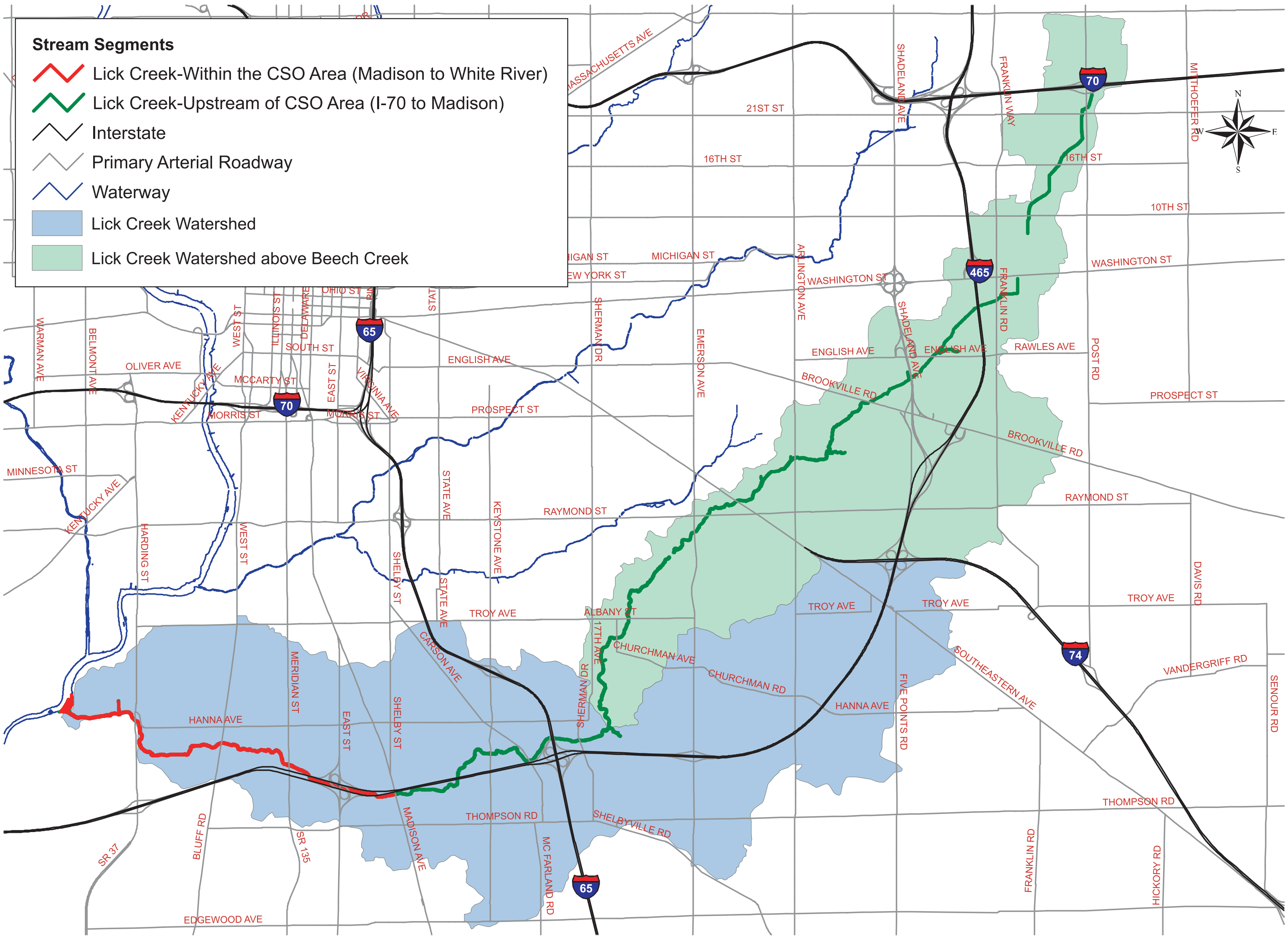

Figure 2-66
Lick Creek Stream Segments

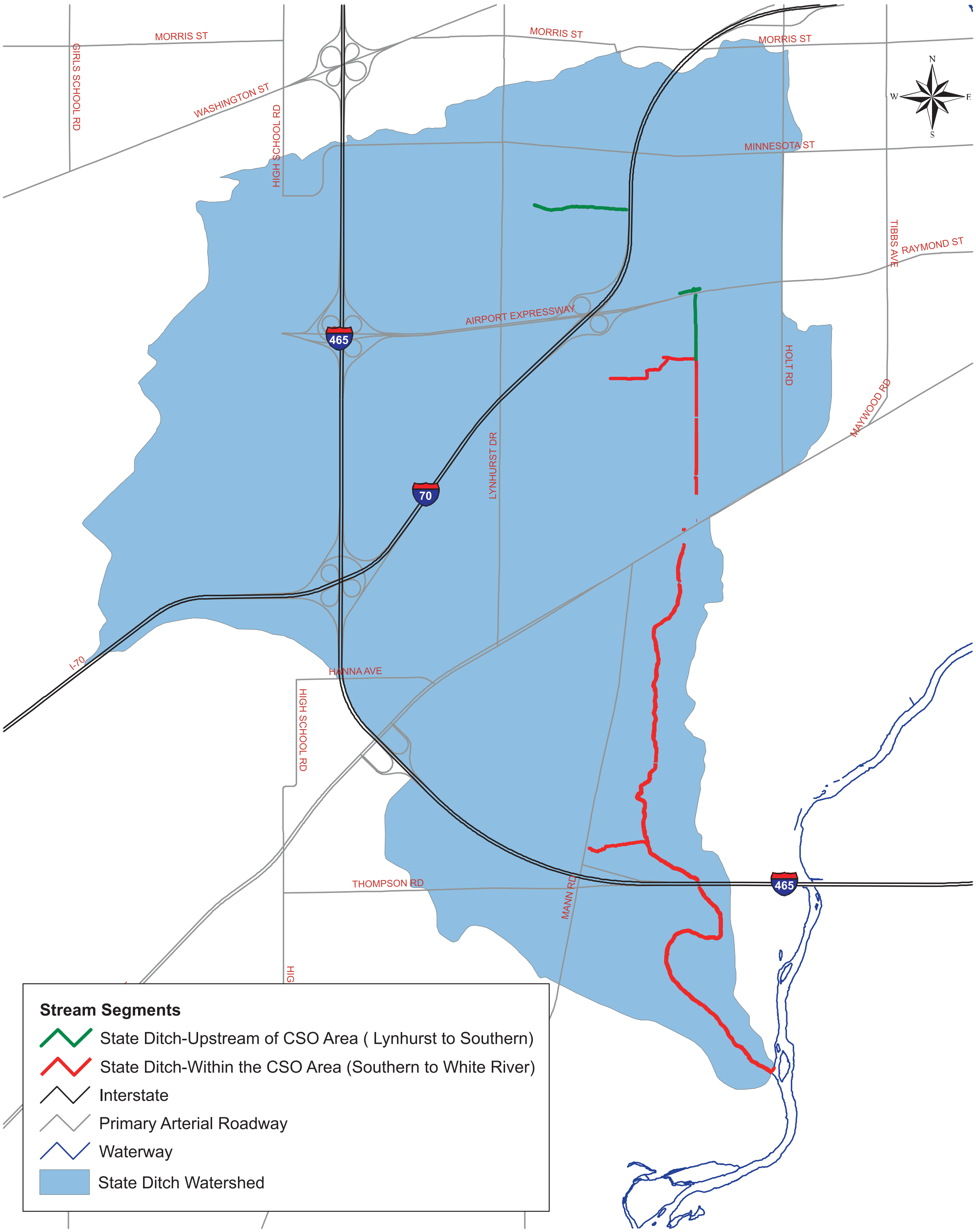

Figure 2-67
State Ditch Stream Segments

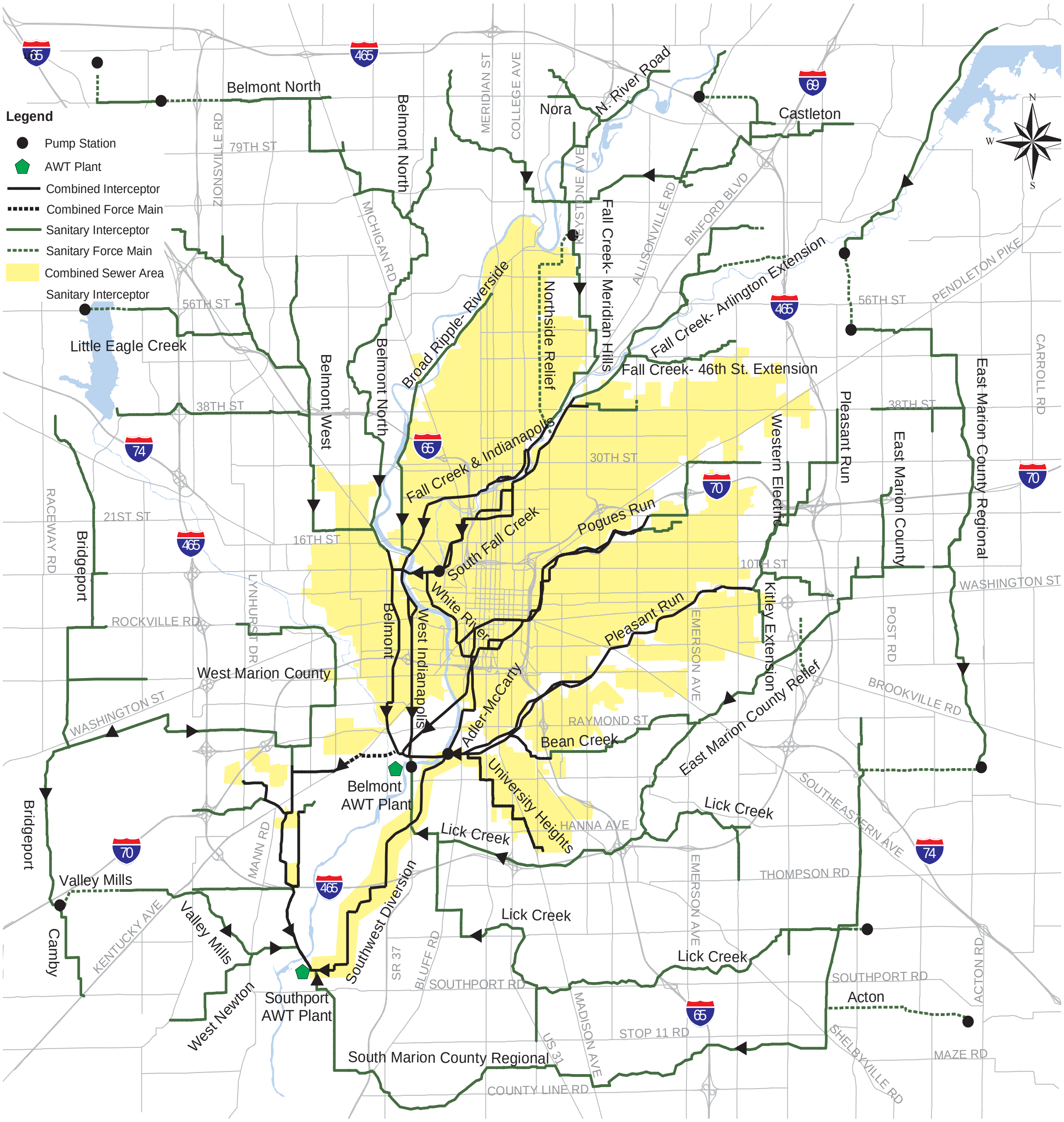

Figure 2-68
Interceptor Network Location Map

Adler-McCarty interceptor, which is part of the core sub-network. Pipe sizes in this interceptor branch range from 15 inches to 78 inches. The overflow point associated with the University Heights Interceptor discharges to Lick Creek.

The Pogues Run interceptor branch is located north of the Pleasant Run/Bean Creek interceptor and contains 11.5 miles of interceptor sewers and 24 overflow points. A total of 5,453 acres of combined sewer area drains into this branch. A large portion of the area served by the interceptor is combined; however, the far upstream portion serves a separately sewered area. This branch also ends at the Adler-McCarty interceptor. Pipe sizes in this interceptor branch vary from 15 inches to 66 inches.

The Fall Creek interceptor branch is located north of the core interceptor and includes both the North and South Fall Creek interceptors. This branch contains 14.7 miles of interceptor sewer and 15,192 acres of combined area draining into 28 overflow points. The North Fall Creek branch ends at the West Indianapolis interceptor while the South Fall Creek branch ends at the White River interceptor but also extends to the West Indianapolis interceptor. Pipe sizes in this interceptor branch vary from 12 inches to 120 inches.

The remaining 13 overflow points are located outside of the major interceptor network branches and the core interceptor sub-network. The breakdown of these overflow points is as follows: four overflow points are located on the Broad Ripple-Riverside interceptor network that contributes to overflows along upper White River. Three overflow points are located on the West Marion County interceptor network, resulting in overflows in lower White River and State Ditch. Five overflow points are on the Eagle Creek and Belmont interceptors, contributing to overflows on Eagle Creek. Finally, one overflow point is located at the Southport AWT plant; it overflows to Little Buck Creek.

2.5.3 Combined Sewer Outfall Points

Table 2-7 summarizes the active combined sewer outfalls as of 2005. The first column in the table denotes the three-digit identification number for each outfall. The table shows the approximate location of each outfall, and the corresponding receiving stream. Five overflow points have been eliminated since 2001; they are shown on the table to document baseline conditions.

2.5.4 Separate Sewer Area

The area outside of the combined sewer area shown in **Figure 2-68** contains separate sanitary and storm sewers. In addition, some neighborhoods outside the combined sewer area are served by septic systems, as described below in Section 2.5.7. Separate sewers are located in all townships, although combined sewers prevail in Center Township. The separate area covers approximately 222 square miles. While most of Marion County has already been developed and sewered, approximately 95 square miles remain undeveloped. These undeveloped and unsewered areas exist in the following townships: Franklin, Pike, Washington, Decatur, and Wayne.

2.5.5 Separate Sewer System Interceptor Network

The city's separate interceptor network is split into two parts: one east and one west of the White River. The network includes 25 major interceptors containing 184.7 miles of sewers, ranging in size from 12 inches to 108 inches, and 11 pump stations. Details of this network are described below and included in **Table 2-8**.

Roughly 50 percent of the separate sewer system discharges to the Southport AWT plant and has no direct impact on the ability of the combined interceptor network and the Belmont AWT plant to capture and treat combined wastewater. The other 50 percent of the separate sewer area discharges into the combined interceptor network (112 out of 222 square miles). Note, however, that the city is developing a project to mitigate CSOs by diverting sanitary flows from the Belmont North and Belmont West interceptors away from the Belmont interceptor. The area served by the Belmont North and Belmont West interceptors is roughly 58 square miles, thereby reducing the percent of the separate area discharging into the combined network to 24 percent. The city has also reduced separated sewer flows into the Fall Creek combined sewer interceptor by diverting flow from some separated sewer areas to the East Marion County Sewer and treating flows at the Southport AWT plant.

The sanitary flow and the wet-weather response associated with the separate sewer system that does discharge into the combined interceptor network has been accounted for in hydraulic modeling. These impacts are generally limited to the upstream areas in the combined interceptor network. For a more detailed description of the hydraulic modeling of separate sewer impacts on CSOs, see the "Indianapolis CSO LTCP Hydraulic and Water Quality Modeling Report" (DPW-

Table 2-7
Combined Sewer Outfalls

ID Number CSO	Watershed Discharging to:	Approximate Location
03A	Little Buck Creek	Southport AWTP
03B	Little Buck Creek	Southport AWTP
008	White River	Belmont AWTP
011	Big Eagle Creek	Minnesota St. & Pershing Ave.
012	White River	Raymond St. & West St.
013	White River	Meridian St. & Adler St.
014	White River	Kentucky Avenue & York Street
015	Bean Creek	Southern Ave. & Manker Ave.
016	Bean Creek	Shelby St. & Willow Dr.
017	Bean Creek	Boyd Ave. & Nelson Ave.
019	Pleasant Run	PLRPND & Meridian St.
020	Pleasant Run	PLRPND & Pennsylvania St.
021	Pleasant Run	PLRPND & Ransdall St.
022	Pleasant Run	PLRPSD & Raymond St.
023	Pleasant Run	PLRPND & Iowa St.
025	Pleasant Run	PLRPND & Shelby St.
027	Pleasant Run	PLRPSD & Cottage Ave.
028	Pleasant Run	PLRPND & State St.
029	Pleasant Run	Orange St. & Randolph St.
030	Pleasant Run	PLRPSD & Randolph St.
031	Pleasant Run	PLRPSD & Churchman Ave.
032	Big Eagle Creek	Morris St. & Warman Ave.
033	Little Eagle Creek	Vermont St. & Somerset Ave.
034	Pogues Run	Michigan St. & Dorman St.
34A	Pogues Run	548 Dorman St.
035	Pogues Run	Arsenal Ave. & 10th St.
036	Pogues Run	Nowland Ave. & Tecumseh St.
037	White River	Washington St. & Geisendorff St.
038	White River	New York St.& University Blvd.
A38	Pogues Run	800 E. Washington St.
039	White River	New York St. & Beauty Ave.
040	White River	New York St. & Koehne St.
041	White River	WRPWD & Michigan St.
042	White River	Saint Clair St.& Miley Ave.
043	White River	Harding St. & Waterway Blvd.
044	White River	Waterway Blvd. & Riverside Dr.
045	White River	WRPWD & Belmont Ave.
046	White River	Lafayette Rd. & 19th St.
049	Fall Creek	Stadium Dr. & Fall Creek
050	Fall Creek	Fall Creek Blvd. & Bursdsal Pkwy.
50A	Fall Creek	Northwestern Ave. & 24th St.
051	Fall Creek	Capital Ave. & 22nd St.
052	Fall Creek	Fall Creek Blvd. & Boulevard Pl.
053	Fall Creek	FCPND & Illinois St.
054	Fall Creek	FCPND & Meridian St.
055	Fall Creek	28th St. & Talbot St.
057	Fall Creek	28th St. & Washington Blvd.
058	Fall Creek	28th St. & New Jersey St.
059	Fall Creek	FCPND & Central Ave.

Table 2-7
Combined Sewer Outfalls - Continued

ID Number CSO	Watershed Discharging to:	Approximate Location
060	Fall Creek	Sutherland Ave. & Central Ave.
061	Fall Creek	FCPND & Ruckle St.
062	Fall Creek	Guilford Ave. & 30th St.
063	Fall Creek	FCPND & 32nd St.
63A	Fall Creek	FCPND & 32nd St.
064	Fall Creek	Winthrop Ave. & 34th St.
065	Fall Creek	Sutherland Ave. & 34th St.
066	Fall Creek	Fall Creek Blvd. & Balsam Ave.
072	Pleasant Run	PLRPND & Saint Peter St.
073	Pleasant Run	PLRPND & Keystone Ave.
074	Pleasant Run	PLRPND & Prospect St.
075	Pleasant Run	PLRPND & Southeastern Ave.
076	Pleasant Run	PLRPSD & English Ave.
077	Pleasant Run	PLRPND & Sherman Ave.
078	Pleasant Run	PLRPSD & Brookville Rd.
079	Pleasant Run	PLRPND & Linwood Avenue
080	Pleasant Run	PLRPND & Wallace Ave.
081	Pleasant Run	PLRPND & Riley Ave.
083	Pleasant Run	Hawthorne Ln. & Lowell Ave.
084	Pleasant Run	PLRPND & Michigan St.
085	Pleasant Run	PLRPND & Ritter Ave.
086	Pleasant Run	PLRPND & Ritter Ave.
087	Pleasant Run	PLRPND & Audubon Ave.
088	Pleasant Run	PLRPND & Graham Ave.
089	Pleasant Run	PLRPND & Arlington Ave.
89A	Pleasant Run	PLRPND & Arlington Ave
090	Pleasant Run	Lowell Ave. & Sheridan Ave.
091	Pleasant Run	PLRPSD & Kenmore Rd.
092	Pleasant Run	PLRPSD & Ridgeview Dr.
095	Pogues Run	BPND & Coyner Ave.
096	Pogues Run	BPSD & Nowland Ave.
097	Pogues Run	BPSD & Keystone Ave.
098	Pogues Run	Tacoma Ave. & Nowland Ave.
099	Pogues Run	BPSD & Temple Ave.
100	Pogues Run	BPSD & Rural St.
101	Pogues Run	Sherman Dr. & BPND
102	Pogues Run	Forest Manor Ave. & 19th St.
103	Fall Creek via Meadow Brook	3900 N. Sherman Dr.
106	Pleasant Run	PLRPND & Orange St.
107	Pleasant Run	PLRPND & Saint Paul St.
108	Pleasant Run	PLRPSD & Saint Paul St.
109	Pleasant Run	PLRPND & Churchman Ave.
115	Pogues Run	Henry St. & Kentucky Ave.
116	White River	Meikel St. & Ray St.
117	White River	Southern Ave. & White River
118	White River	WRPED & West St.
119	Pleasant Run	PLRPSD & Beecher St.
120	Pleasant Run	PLRPSD & Southern Ave.
125	Pogues Run	Meridian St. & South St.

Table 2-7
Combined Sewer Outfalls - Continued

ID Number CSO	Watershed Discharging to:	Approximate Location
127	Pleasant Run	1325 S. State
128	Pogues Run	Senate Ave. & Merrill St.
129	Pogues Run	Meridian St. & Merrill St.
130	Pleasant Run	Manual High School
131	Fall Creek	Fall Creek Blvd. & Capitol Ave.
132	Fall Creek	FCPND & Pennsylvania St.
133	Pogues Run	Market St. & Pine St.
135	Fall Creek	Orchard Avenue & 39th St.
136	Pogues Run	New York St. & Dorman St.
137	Pogues Run	Pine St. & Ohio St.
138	Pogues Run	College Ave. & Washington St.
141	Fall Creek	College Ave. & 38th St.
142	Fall Creek	College Ave. & 38th St.
143	Pogues Run	Forest Manor Ave. & 21st St.
145	Big Eagle Creek	Raymond St. & Kentucky Ave.
147	White River	WRPWD & Vermont St.
148	Pleasant Run	PLRPND & Madison Ave.
149	Pleasant Run	PLRPSD & Garfield Dr.
150	Pleasant Run	PLRPND & Raymond St.
151	Pleasant Run	PLRPND & Beecher St.
152	Pogues Run	Pine St. & Ohio St.
153	Pogues Run	Illinois Ave. & Merrill St.
154	Pleasant Run	PLRPND & Michigan St.
155	White River	5600 N. Kenwood
156	White River	Kenwood Ave. & Westfield Blvd.
205	White River	Boulevard Pl. & Westfield Blvd.
210	Fall Creek	Indiana Ave. & 10th St.
213	Fall Creek	Hillside Ave. & 29th St.
216	Fall Creek	Crittenden Ave. & 42nd St.
217	State Ditch	Gadsden St. & Lyons Ave.
218	State Ditch	Gadsden St. & Fleming St.
223	Big Eagle Creek	Victoria St. & Warman Ave.
224	Pleasant Run	PLRPND & Washington St.
226	Pleasant Run	PLRPND & Colorado Ave.
227	Pleasant Run	5702 E. Michigan
228	Pleasant Run	Michigan St. & Graham Ave.
229	Pleasant Run	PLRPND & Arlington Ave.
235	Lick Creek	Shelby St. & Markwood Ave.
275	White River	4945 S. Foltz

PLRPND Pleasant Run Pkwy. N. Dr.
PLRPSD Pleasant Run Pkwy. S. Dr.
WRPWD White River Pkwy. W. Dr.
WRPED White River Pkwy. E. Dr.
FCPND Fall Creek Pkwy. N. Dr.
BPND Brookside Pkwy. N. Dr.
BPSD Brookside Pkwy. S. Dr.

Eliminated

Table 2-8
Separate Sewer System Interceptor Inventory

Interceptor	Township	Pipe Size (inches)	Length (miles)
West Side of White River			
Belmont North	Pike, Washington	27 to 42	13.8
Little Eagle Creek	Pike	12 to 18	3.8
Belmont West 38th Street	Pike, Wayne	24 to 30	4.2
Belmont West	Pike, Wayne	30 to 42	6.6
West Marion County	Wayne, Decatur	15 to 72	10.1
Bridgeport	Wayne, Decatur	15 to 48	10.6
Camby	Decatur	24 to 30	2.3
Valley Mills	Decatur	54 to 66	5.7
West Newton	Decatur	30	2.7
East Side of White River			
Nora	Washington	18 to 24	2.2
North River Road	Washington	18 to 48	4.6
Williams Creek	Washington	12 to 42	5.8
Castleton	Lawrence, Washington	14 to 42	5.3
Fall Creek/Meridian Hills	Washington	30 to 36	4.4
Fall Creek/Arlington Extension	Lawrence, Washington	12 to 42	12.2
Fall Creek 46th Street Extension	Lawrence, Washington	21 to 24	2.5
East Marion County	Lawrence, Warren	36	3.4
East Marion County Regional	Lawrence, Warren	15 to 60	21.7
Franklin Regional	Franklin	18 to 30	8.9
South Marion County Regional	Franklin, Perry	21 to 108	20.5
Western Electric	Warren	24 to 36	2.3
Kitley Extension	Warren	24 to 42	1.1
East Marion County Relief	Warren, Center, Perry	18 to 36	10.8
Lick Creek (Section 1 through 4)	Franklin, Perry	18 to 66	21.6
Lick Creek Shelby Street Extension	Perry	30	1

ICST, 2004), located in **Appendix A** of this report. As an example, the city's model predicts that for a three-month storm, 11 percent of the total flow through the combined interceptor network comes from the separately sewered areas. One-third of that 11 percent is the wet-weather response in the separate system.

The city's separate interceptor network on the east side of the White River has three interceptor branches: the East Marion County, the East Marion County Regional, and the Franklin Regional. These interceptor branches ultimately flow into the South Marion County Regional interceptor, which conveys sewage directly into the Southport AWT plant.

In addition to these separate interceptors, other separate interceptors on the north, south and east sides flow into the combined interceptor network. In the north, the following separate interceptor branches discharge into the combined Fall Creek interceptors: Williams Creek, Nora, North River Road, Castleton, Fall Creek-Meridian Hills, Fall Creek Arlington Extension, and Fall Creek 46th Street Extension. In the east, the Western Electric and the Kitley Extension interceptor branches flow into the combined Pleasant Run interceptor at the upstream end. Lastly, in the south, the following separate interceptor branches discharge into the combined Southwest Diversion interceptor: the East Marion County Relief (upper and lower), the Lick Creek (Section 1 through 4), and the Lick Creek Shelby Street Extension.

The city's separate interceptor network on the west side of the White River has four branches: Bridgeport, Camby, West Newton, and Valley Mills. These interceptor branches flow into the West Marion County interceptor, which conveys sewage directly to the Southport AWT plant. A wet-weather bypass from the Belmont AWT plant to the West Marion County interceptor also exists that can divert 30 mgd of pumped flow from the Belmont to the Southport AWT plant. Other separate interceptors also flow into the combined interceptor network on the west side. In the northwest, the Little Eagle Creek and Belmont West 38th Street interceptor branches into the Belmont West interceptor. This interceptor and the Belmont North interceptor ultimately discharge into the combined Belmont interceptor.

2.5.6 Separate Sewer Outfall Points

Approximately 40 years ago, sanitary sewer overflows (SSO) were designed and constructed as critical relief structures at 16 locations within the city's sanitary network. Since the late 1980s, the city has eliminated all but three of these sanitary sewer overflow points. The remaining overflows include SSO 113 associated with the Bridgeport interceptor, and SSO 124 and SSO 105 associated with the Fall Creek Arlington Extension interceptor. The city is implementing plans to eliminate these overflows by 2007.

2.5.7 Private Septic Systems

Within Marion County, an estimated 30,000 properties are served by private septic systems. Septic systems generally have a limited design life and eventually fail, resulting in potential surface and groundwater contamination. The health and environmental risks associated with septic failures are well documented in the 2003 TMDL studies and other publications. Neighborhoods served by septic systems are typically located just outside the old City of Indianapolis limits, as shown in **Figure 2-69**. The city has historically used the state's Barrett Law to finance the conversion of properties served by septic systems to sanitary sewers. As part of its 2001 long-term control plan, the city proposed accelerating its septic conversion program from a 60-year plan to a 20-year schedule. From 2000-2004, the city extended sewer service to six neighborhoods serving 414 homes and businesses.

2.6 Treatment Plant Design and Characterization

Wastewater flows in the Indianapolis collection system are treated at one of two AWT plants. These plants, known as the Belmont and Southport AWT plants, are located along the Lower White River. Approximate locations of the AWT plants, relative to streams and major interceptors, are shown on **Figure 2-68**. The Belmont AWT plant is situated at the confluence of Eagle Creek and White River. Its effluent (Outfall 006) discharges directly to the White River. The Southport AWT plant is located approximately 5 miles downstream at the confluence of Little Buck Creek and the White River. Its effluent (Outfall 001) also discharges directly to the White River.

The Belmont AWT plant receives sanitary and wet-weather flow predominately from the north and east sides of Marion County, as well as from Center Township (which encompasses a majority of the CSO area). Flows are conveyed through the following five major interceptors:

- Belmont Interceptor
- West Indianapolis Interceptor
- Harding Street Interceptor
- Adler-McCarty Interceptor
- Pleasant Run Interceptor

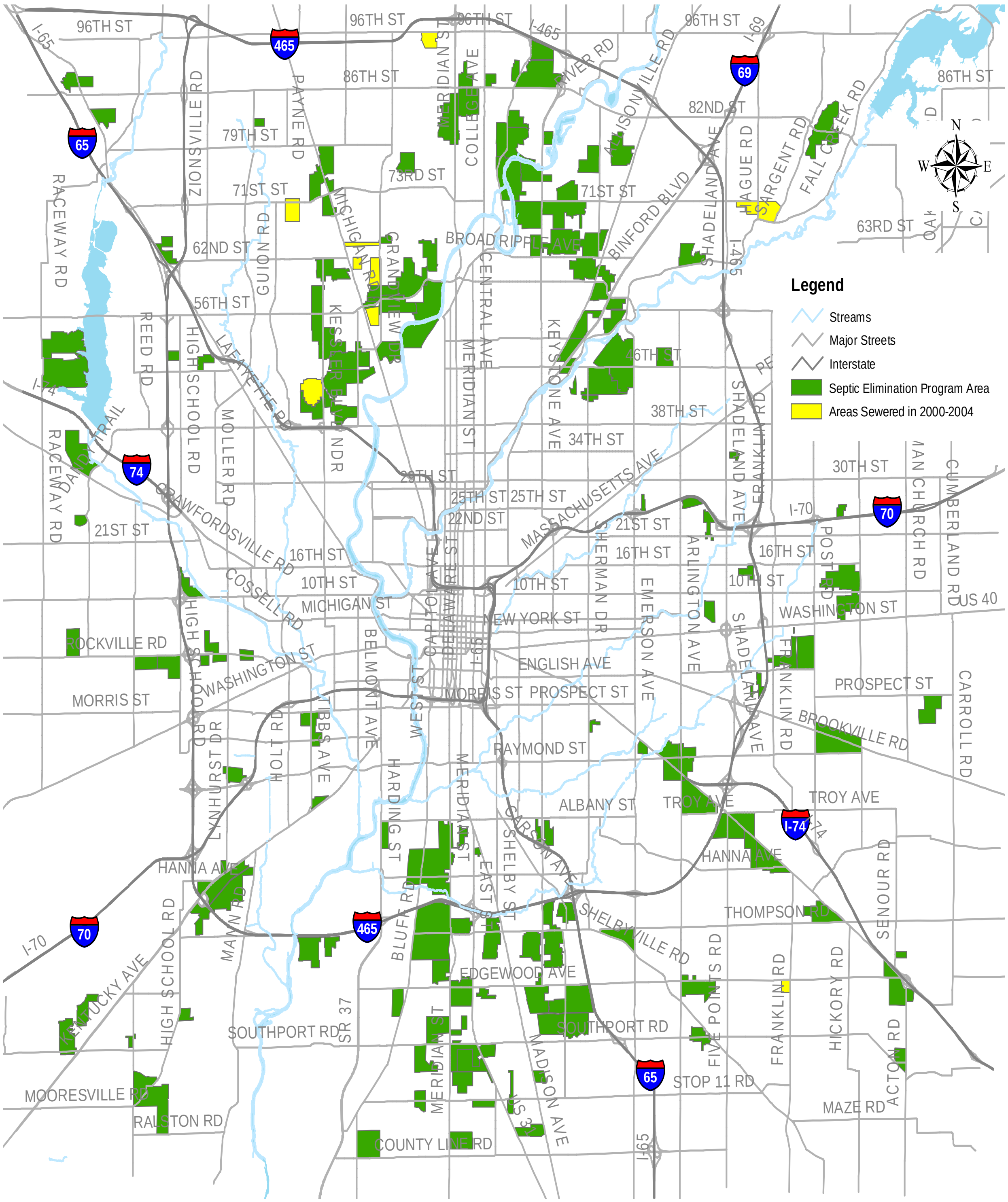

Figure 2-69
Septic Tank Elimination Program

The Southport AWT plant receives sanitary and wet-weather flow predominately from the east, west and south sides of Marion County, as well as from the City of Greenwood in northern Johnson County. Flows are conveyed through the following four major interceptors:

- South Marion County Regional (Greenwood) Interceptor
- Southwest Diversion (Southern Avenue) Interceptor
- West Marion County (Tibbs) Interceptor
- Valley Mills Interceptor

A majority of the wet-weather flow from the City's CSO system is conveyed to the Belmont AWT plant. However, during significant wet-weather events some of the Belmont flow may be diverted to the Southport AWT plant by one of three methods as shown on **Figure 2-70** (*Wet Weather Diversion Schematic)*. First, approximately one-third of the capacity of the Adler-McCarty Interceptor may be diverted away from the Belmont AWT by opening a 60-inch gate at the Southwest (Southern Avenue) Diversion Structure located along the east bank of the White River across from the Belmont AWT plant. A second method involves the use of a wet-weather pump station at the Belmont plant to pump up to 30 mgd of raw sewage to the Southport AWT plant via the Tibbs Interceptor. A third method uses an existing gravity line to divert up to 17 mgd of degritted sewage to the Southport AWT plant via the Tibbs Interceptor. The second and third methods take advantage of the same pipe and therefore cannot be operated concurrently.

Several engineering studies have been completed that included capacity assessments of the Belmont and Southport AWT plants for treating both wet- and dry-weather flows. An initial series of analyses that focused on the Belmont AWT plant was completed in 2001 (White River Environmental Partnership (WREP), 2001). A follow-up analysis that assessed the benefits of wet-weather storage basins at both plants was completed in 2002 (CDM, 2002). Most recently, facility planning analyses were completed that focused on a new interplant connection and the Southport AWT facility (ICST, 2004). Collectively, these studies included detailed reviews of plant information, design criteria, and operational data relevant to the strategic planning issues. They included activities such as review of previous engineering studies and facility plans; analysis of existing data to characterize long-term, seasonal, in-plant recycle and wet-weather loadings; preparation of simplified drawings such as process flowsheets; review of upcoming non-CSO capital improvements; analysis of CSO abatement improvements thus far completed; and identification of plant site areas that could accommodate new CSO abatement facilities. Baseline conditions at the Belmont and Southport AWT plants are described in the text that follows.

Based on an assessment of seven consecutive years of daily flow data (i.e., 1996 through 2002), the long-term average dry-weather flowrate for the Belmont/Southport AWT plant system was estimated to be approximately 156 mgd. Of this, approximately 93 mgd was directed to the Belmont AWT plant with the remaining 63 mgd directed to the Southport plant. Flow peaking due to wet-weather contributions and seasonal infiltration was significantly more pronounced at the Belmont plant. Peak monthly average flowrates sometimes reach about 200 mgd at the Belmont plant, whereas they seldom exceed 100 mgd at the Southport plant. Ninety-nine percent of the time, daily average flowrates are less than about 300 mgd at the Belmont plant and less than about 150 mgd at Southport. During extreme wet-weather conditions, however, peak hourly flowrates of about 600 mgd and 270 mgd have been observed at the Belmont and Southport plants, respectively.

2.6.1 Belmont AWT Plant - Baseline Operational Conditions

The Belmont AWT plant was first placed in service in 1924 as a primary clarification plant. In May 1925, a 50-mgd activated sludge plant was put in service to serve a connected population of 300,000. This was among the first large activated sludge facilities in the country. In 1936 the Belmont plant was expanded to add three aeration tanks and 12 final clarifiers. In 1954, new primary settling tanks, aerated grit tanks, and preaeration channels were put into operation. In 1955, the plant was expanded to provide secondary treatment for flows up to 120 mgd. It was upgraded again in the late 1970s through early 1980s to provide tertiary treatment (nitrification and filtration) for average flows up to 120 mgd and peak flows up to 150 mgd. Solids handling improvements were added in the late 1980s.

In recent years the city has initiated several projects to upgrade and expand the Belmont AWT plant. This section documents baseline plant conditions prior to December 2001. **Table 2-9** summarizes the basis of design for the baseline Belmont AWT plant configuration. Unit operations at the Belmont AWT plant are shown on **Figure 2-71** *(Belmont AWT Plant Process Flow Schematic).*

2.6.1.1 Belmont Preliminary Treatment

Combined wastewater and stormwater flows are conveyed through five interceptor sewers: Alder-McCarty, Harding Street, Pleasant Run, West Indianapolis, and Belmont. Flows from all five interceptors are combined and enter the Belmont

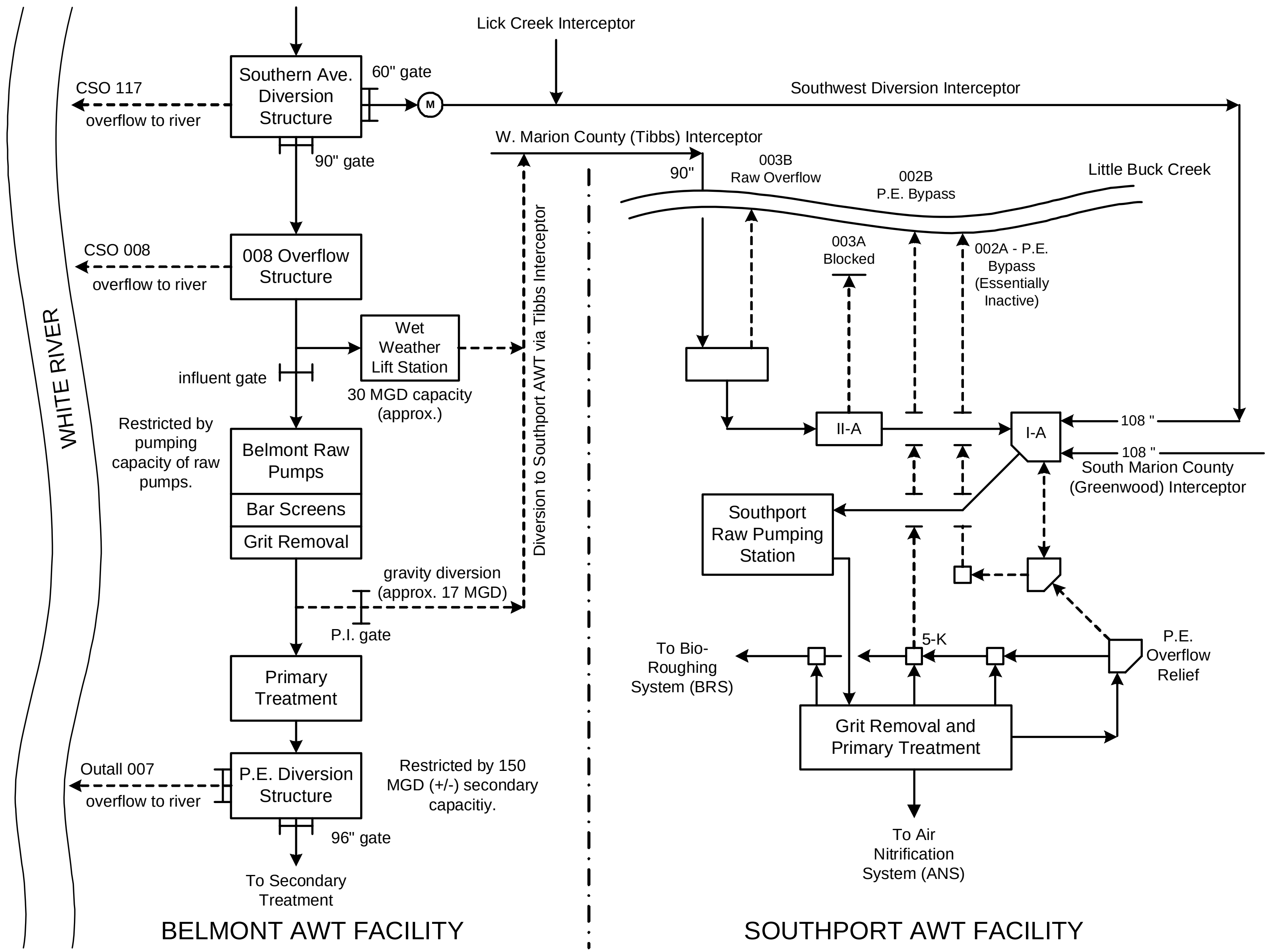

Figure 2-70
Wet Weather Diversion Schematic

Table 2-9
Belmont AWT Plant - Baseline Design and Loading Criteria

Treatment Process / Units	Unit Description	Capacity
Preliminary Treatment		
Trash Racks	3 - 150 mgd Mechanically Racked Trash Racks with 4-inch spacings located in three 10-foot wide channels	300 mgd (Firm Peak)
Raw Sewage Pumps	10 - 33 mgd Screw Pumps	297 mgd (Firm Peak)
Mechanical Bar Screens	5 - 75 mgd Mechanically Cleaned	300 mgd (Firm Peak)
Aerated Grit Tanks	5 - 75 mgd	300 mgd (Firm Peak)
Primary Treatment		
Primary Clarifiers	4 - 265’ L x 64’ W x 15’ D Tanks	
	1 - 265’ L x 88’ W x 15’ D Tanks	
- Total Surface Area	91,160 SF	
- Average Flow	At 1,000 gpd / SF overflow rate	91.2 mgd
	At 1,371 gpd / SF overflow rate	125 mgd (Design Avg. Flow)
- Peak Hourly Flow	At 3,000 gpd / SF overflow rate	273.6 mgd
Primary Sludge Pumps	6 - 800 gpm Pumps	4,000 gpm
Secondary Treatment	**Carbonaceous BOD Removal**	
Bio-Roughing Pump Station	30,900 CF Wet Well volume or 231,132 gallons	Detention Time of 2.2 minutes at 150 mgd
	4 - 50 mgd Horizontal Centrifugal Pumps with VFDs rated at 34,725 gpm at 64 ft. TDH at 500 rpm	150 mgd (Firm Peak)
Bio-Roughing Towers	4 - 150’ dia. x 21.5’ Deep Towers with self supporting 149 ft. dia. plastic media	
- Media Surface Area	17,436 SF each (69,744 SF total)	
- Media Volume	374,874 CF each (1,499,496 CF total)	Calc. by JTP/DPW
- Avg. Organic Loading	84 lbs BOD_5 / 1000 CF / day	
- Vol. Surface Ratio	Plastic media - 27 SF / CF	
- Avg. Hyd. Loading Rate	1.25 gpm / SF (4 towers in use)	125 mgd
- Peak Hyd. Loading Rate	2.0 gpm / SF (3 towers in use)	150 mgd (Firm Peak)
- Min. Hyd. Loading Rate	0.5 gpm / SF (4 towers in use)	50.2 mgd

References:
1.) "Preliminary Assessment of Wet Weather Improvements for Belmont AWT Facility (Phase II)," WREP (May 1998)
2.) “A Guide to the Belmont Advanced Wastewater Treatment Facility,” Indianapolis DPW bulletin (January 1984 approx.)
3.) “Task 1 Report - Review of Existing Belmont and Southport AWT Facilities, " WREP (February 2001)
4.) Based on observations made by City staff.
5.) “Recommended Standards for Sewage Works,” 1997 Edition.
6.) “Operator's Guide" (1987)
7.) 1977 Design Summary for the Southport AWT Plant by Reid, Quebe, Allison, Wilcox & Associates, Inc.

Table 2-9
Belmont AWT Plant - Baseline Design and Loading Criteria - Continued

Treatment Process / Units	Unit Description	Capacity
Tertiary Treatment	**Nitrification**	
ONS Pump Station	6 - 132-inch dia. Open Archimedean Screw Pumps at 55,034 gpm design cap. per pump at 22 rpm and max. 17.69 ft. TDH	317 mgd with 2 of 3 pumps running per side (4 total of 6)
Oxygen - Nitrification System	6 - 60' L x 60' W x 15' D Tanks With 8 Stages / Train	
- Average Flow		125 mgd (Avg. Daily)
- Peak Flow		150 mgd (Peak Daily)
- Design Average BOD_5 Load	38 lb BOD_5 / 1000 CF	
- Design Average NH_3 Load	6.4 lb. NH_3 / 1000 CF	
- MLVSS Range	2600 - 4000 mg/L	
- Mean Cell Res. Time	13 days (max.)	
- Oxygen Generation	Vacuum Swing Absorption	
- Cryo O_2 Capacity	180 tons per day	Currently operated w/ VSA rated at 120 ton/day
- Liquid O_2 (LOX) Storage	1,000 tons w/ 225 ton/day vaporization cap.	LOX backup system provided by Air Liquide (2 - 13,100 gallon tanks)
- Ambient Vaporizers	2 - 120,000 scf per hour	
ONS - Final Clarifiers	10 - 245' L x 90' W x 14.78' D Rectangular Clarifier with sludge removal by travelling bridge siphon collectors	
- Design Average Flow	At 473 gpd / sf overflow rate	125 mgd (Avg. Daily)
- Peak Flow (Max. Day)	At 568 gpd / sf overflow rate	150 mgd (Peak Daily)
- Peak Hourly Flow (Ten States)	At 800 gpd / sf overflow rate	211 mgd (Peak Hourly)
Tertiary Treatment	**Effluent Filtration**	
Effluent Filters	12 - Mixed Media (Anthracite Coal and Sand) Filters with 2 cells per filter	Note: The filter media was replaced with coarse mono-media sand in 1995.
- Dimensions per Filter Cell	61 ft. L x 15.25 ft. W with 20-inch anthracite coal, 7 inch sand, and 12 inch gravel layers. The filter media was replaced with course mon-media sand in 1995.	Coal Layer Missing
- Surface Area per Cell	930 SF	2 Cells per Filter
- Total Surface Area	22,320 SF	For all 24 Filter Cells
- Average Flow	At 4.41 gpm / sf (11 Filters)	131 mgd (120 mgd Avg. Flow plus 11 mgd washwater recycle)
- Peak Flow	At 5.29 gpm / sf (11 Filters)	156 mgd (145 mgd Avg. Flow plus 11 mgd washwater recycle)
- Peak Flow	At 5.0 gpm / sf (11 Filters)	147.4 mgd (Peak Hourly)
Effluent Disinfection	4 - 110' L x 25' W x 16' SWD Ozone Contact Tanks with 4 stage over and under baffling	Ozone off line with temp. Liquid NaOCl Bleach disinfection system installed by WREP in 1995, sodium bisulfite used for dechlorination
- Contact Tank Vol. each	44,000 CF or 329,120 gallons	
- Contact Tanks Volume Total	176,000 CF or 1,300,000 gallons	
- Average Flow	Contact Time @ 125 mgd	15 minutes (Peak w/ Chlorine)
- Peak Flow	Contact Time @ 160 mgd	11.7 minutes (Peak w/ Ozone)

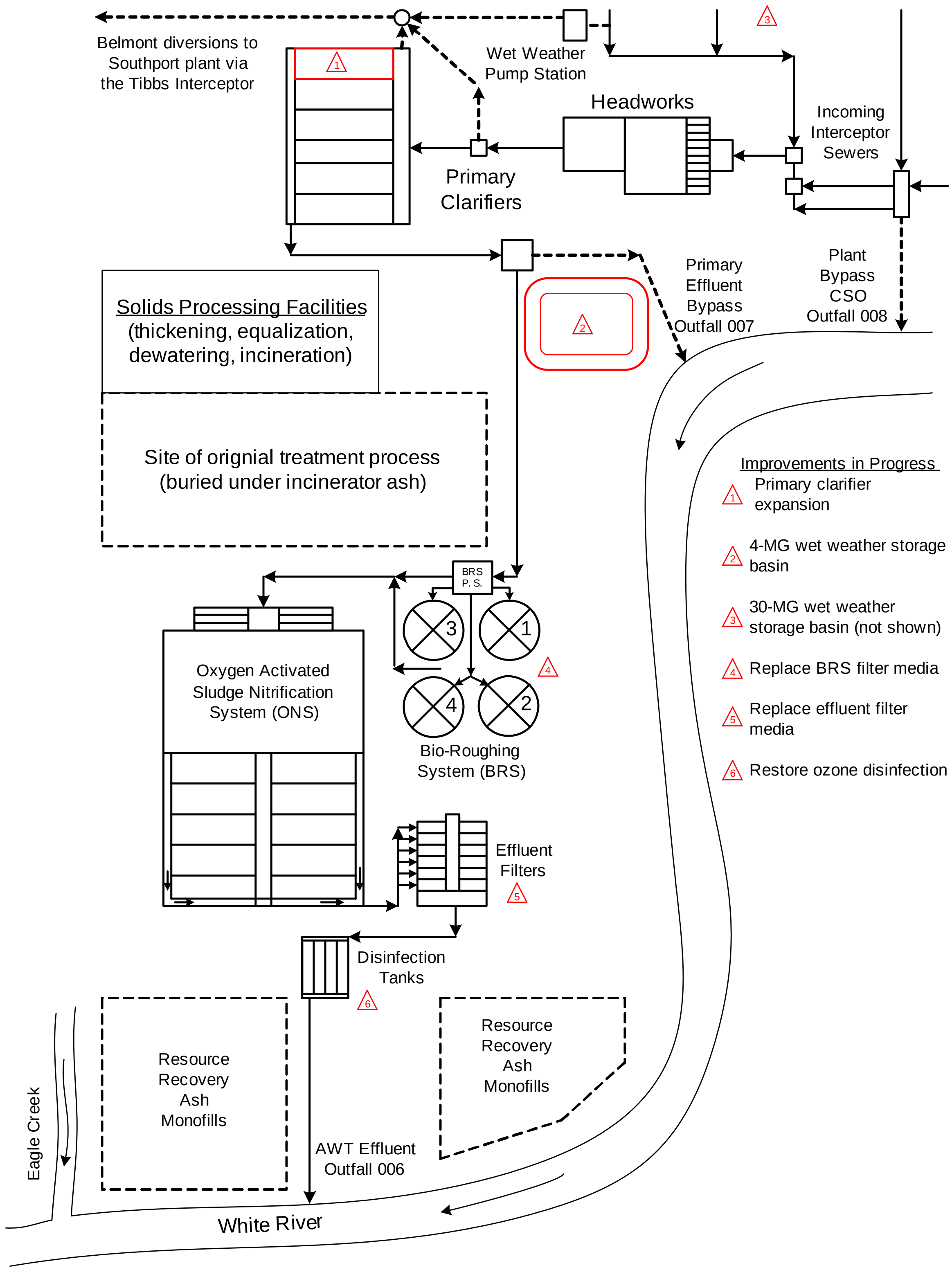

Figure 2-71
Belmont AWT Plant Process Flow Schematic

AWT through a 10-by-10-foot influent sewer. A wet-weather pumping station was constructed in 1997 that can transfer raw sewage from the Belmont interceptor to the Southport plant (via the Tibbs Interceptor) at a peak rate of about 30 mgd.

Raw wastewater entering the headworks facility is split into three parallel channels. Each channel is equipped with a trash rack that is mechanically cleaned, inclined, and front raking with 4-inch clear openings. The trash racks remove large pieces of wood, trash, and debris prior to influent pumping.

Influent wastewater is pumped by ten open Archimedean screw pumps into a common bar screen influent channel and is split among five parallel channels. All ten of the pumps were replaced in 2002 and each is rated at 33 mgd under optimum conditions. Therefore, the firm pump capacity (i.e., design capacity with one pump out of service) is 297 mgd. The pump ratings are based on the assumption that each pump is brand new and that influent flows are at an optimum level (a condition that is seldom, if ever, achieved). Flow then passes through five parallel channels containing bar screens that are mechanically cleaned, inclined, and front-raking with 1-inch clear openings.

Flow then passes through five aerated grit chambers. Diffusers near the bottom of the chambers provide air that suspends light organic solids while allowing the heavier inorganic solids such as sand, gravel, and cinders to settle to the bottom of the chambers.

Effluent from the aerated grit chambers can be diverted to the Southport AWT plant by gravity at a rate of about 17 mgd, provided the 30 mgd wet-weather pumping station is not in service. Flow that exceeds the raw sewage pumping capacity overflows to the White River at CSO Outfall 008 upstream of the Belmont headworks.

2.6.1.2 Belmont Primary Treatment

After preliminary treatment, the wastewater is settled to remove settleable and floatable solids in five rectangular primary clarifiers. The city began construction on two additional primary clarifiers in early 2004. The clarifiers reduce the suspended solids and organic loading from the wastewater before secondary treatment. The existing primary clarifiers are rated according to Ten States Standards for an average flow of 91 mgd (at a surface overflow criterion of 1,000 gpd/sf) and a peak hourly flow of 274 mgd (at a surface overflow criterion of 3,000 gpd/sf). They can hydraulically handle up to 300 mgd, at which point the primary clarifiers flood.

2.6.1.3 Belmont Secondary Treatment

Primary effluent is pumped to four biological roughing towers having a firm capacity of 150 mgd (assuming one tower is out of service). The aerobic biological roughing towers reduce soluble BOD loads prior to oxygen nitrification.

Effluent from the biological roughing towers is conveyed to the Oxygen Nitrification System (ONS) mixing structure where it combines with return activated sludge. Six screw pumps convey mixed liquor to six ONS reactors, each with eight stages. Each stage is equipped with a mechanical aerator for mixing and oxygen transfer to the wastewater for BOD and ammonia removal. Flow passes through the stages in a serpentine manner to minimize short-circuiting. The ONS is designed for an average daily flow of 120 mgd plus 5 mgd of recycle flows from solids handling.

Effluent from the ONS flows by gravity to twelve rectangular secondary clarifiers having an average daily design capacity of 125 mgd and a peak hourly flow capacity of 150 mgd. Currently, primary effluent flow that exceeds secondary treatment peak capacity (150 mgd) is bypassed at Diversion Structure 007 to the White River.

2.6.1.4 Belmont Tertiary Treatment

Secondary clarifier effluent flows by gravity to twelve effluent filters that remove residual suspended solids. Flow passes through the filter media, is collected by the underdrain system, and flows to the ozone contact tanks. The filter media at the Belmont AWT plant consists of a top layer of anthracite, a second layer of silica sand, and a bottom layer of garnet sand. The design average flow is 131 mgd with a design peak hourly effluent filtration capacity of 156 mgd.

Filtered effluent flows by gravity to the four chlorine contact tanks for disinfection during the April-October recreational season before being discharged to White River via Outfall 006. Sodium hypochlorite and sodium bisulfite are used for effluent chlorination and dechlorination, respectively. The disinfection process reduces the concentration of bacteria in the treatment plant effluent. Disinfectants are added prior to the effluent filters to allow sufficient contact times.

The city is moving forward to replace the chlorination disinfection system with an ozonation system at the AWT plants. Treating the effluent flow with ozone will allow the city to improve the dissolved oxygen conditions in White River and to avoid the problems associated with the byproducts of chlorination and dechlorination. Flows in excess of ozonation capacity will still be treated with sodium hypochlorite and sodium bisulfite for chlorination and dechlorination.

2.6.2 Southport AWT Plant - Baseline Operational Conditions

The Southport AWT plant was first placed in service in July 1966 as a 28 mgd secondary (activated sludge) treatment plant. The capacity was later doubled to 56 mgd. Similar to the Belmont AWT plant, it was upgraded in the late 1970s through the early 1980s to provide tertiary (advanced) treatment for daily average flows up to 125 mgd and peak hourly flows up to 150 mgd.

Table 2-10 summarizes the bases of design for the baseline configuration at the Southport AWT plant. Unit operations at the Southport AWT plant are shown on **Figure 2-72** *(Southport AWT Plant Process Flow Schematic)*.

2.6.2.1 Southport Preliminary Treatment System

Wastewater is conveyed to the Southport AWT plant facility through four interceptor sewers: West Marion County (Tibbs), Southwest Diversion, Valley Mills, and South Marion County (Greenwood). Flows from all three interceptors are combined and enter the Southport AWT plant through a 132-inch influent sewer.

Three mechanically cleaned bar screens with 1/2-inch spacing are located in parallel channels in the Raw Sewage Pumping Station. Four horizontal centrifugal pumps are used to lift raw wastewater to the aerated grit process. Flow passes through two aerated grit chambers and onto a flow splitting structure where the grit effluent can be sent to one of two sets of primary clarifiers. Wet-weather flow that exceeds preliminary treatment capacity (150 mgd) overflows at Outfall 003A into Little Buck Creek, a tributary to the White River. A second outfall, Outfall 003B, has been blocked and is no longer in service.

2.6.2.2 Southport Primary Treatment

Primary settling consists of two sets of four circular, center-feed clarifiers. Horizontal vortex-type pumps remove primary sludge from individual hoppers. Due to their shallow depth, the primary clarifiers are rated for an average daily flow of 57 mgd and a peak hourly flow of approximately 150 mgd.

2.6.2.3 Southport Secondary Treatment

Primary effluent is pumped to four biological roughing towers having a firm design capacity of 150 mgd. The aerobic biological roughing towers reduce the influent soluble BOD loading to the oxygen nitrification system. Effluent from the biological roughing towers is conveyed to either the Oxygen Nitrification System (ONS) or to the Air Nitrification System (ANS) or both. In the ONS process, a mixing structure is used to combine the effluent from the bioroughing towers with the return sludge from the ONS process. Six screw pumps convey the mixed liquor to ten ONS reactors, each with four stages. Each stage is equipped with a mechanical aerator for mixing and oxygen transfer to the wastewater for BOD and ammonia removal. Flow passes through the stages in a serpentine manner to minimize short circuiting. The ONS was designed to treat an average daily flow of 95 mgd and a peak hourly flow of 131 mgd. The Southport ONS reactors are operated using air rather than high purity oxygen but will be returned to the oxygen mode after completion of a project to upgrade the oxygen supply system. Effluent from the ONS flows by gravity to ten rectangular secondary clarifiers capable of settling peak hourly flows up to 176 mgd (at 800 gpd/sf).

In the ANS process, air is diffused into the aeration tanks using coarse pore diffusers. Process air is supplied to the diffusers using 14 centrifugal blowers that range in size from 250 to 500 horsepower. The ANS is rated to treat average daily and peak hourly flows of 30 mgd. Effluent from the ANS flows by gravity to two sets of four circular, center-feed secondary clarifiers capable of settling flows up to 50 mgd (at 800 gallons per day/square foot (gpd/sf)). However, the intermediate pump station capacity from the ANS to the effluent filters is 30 mgd.

Primary effluent flow that exceeds secondary treatment capacity is bypassed at Outfalls 002A or 002B. The primary effluent bypasses into Little Buck Creek, a tributary to the White River.

2.6.2.4 Southport Tertiary Treatment

Secondary clarifier effluent from ONS flows by gravity to 12 effluent filters that remove residual suspended solids. Secondary clarifier effluent from ANS has to be pumped to the effluent channel of the ONS clarifiers before filtration. Flow passes through the filter media, is collected by the underdrain system, and flows to the ozone contact tanks for disinfection. The effluent filters consist of multimedia similar to those at the Belmont AWT. The peak hourly effluent filtration capacity is approximately 150 mgd.

Table 2-10
Southport AWT Plant - Baseline Design and Loading Criteria

Treatment Process / Units	Unit Description	Capacity
Preliminary Treatment		
Mechanical Bar Screens	3 - 75 mgd Mechanically Cleaned Catenary Bar Screens with 1/2-inch Clear Openings Inclined at a 75 Degree Slope to the Horizontal	150 mgd (Firm Peak)
Raw Sewage Pump Station	11,250 CF Wet Well Volume or 84,150 gallons	Detention Time of 0.8 minutes at 150 mgd
	4 - 50 mgd Horizontal Centrifugal Pumps with VFDs rated at 35,000 gpm at 47 ft. TDH at 385 rpm	150 mgd (Firm Peak)
Aerated Grit Chambers	2 - 95' L x 25' W x 15' SWD	The operators report the need for partial bypass at flows above 130-135 mgd
	At 2.55 minutes detention time	150 mgd (Peak Hourly)
	At 3 minutes detention time (minimum)	127.9 mgd
	At 5 minutes detention time	76.7 mgd
Primary Treatment		
Primary Clarifiers	8 - 95’ dia. x 8.25’ SWD Circular, Center Feed with Mechanical Sludge Collectors and Surface Grease Skimmers	
- Surface Area Each	7,088 SF	
- Surface Area Total	56,704 SF	
- Average Flow	At 1,000 gpd / SF surface overflow rate	56.7 mgd
- Peak Hourly Flow	At 1,500 gpd / SF surface overflow rate	85 mgd
	At 2,204 gpd / SF surface overflow rate	125 mgd (Design Avg. Flow)
	At 2,821 gpd / SF surface overflow rate	160 mgd (Max. Flow)
Secondary Treatment	**Carbonaceous BOD Removal**	
Bio-Roughing Pump Station	27,830 CF wet well volume or 208,168 gallons	Detention Time of 2.0 minutes at 150 mgd
	4 - 50 mgd Horizontal Centrifugal Pumps with VFDs rated at 34,725 gpm at 60 ft. TDH at 500 rpm	150 mgd (Firm Peak)
Bio-Roughing Towers	4 - 150’ dia. x 21.5’ deep towers with self supporting 149 ft. dia. plastic media	
- Media Surface Area	17,436 SF each (69,744 SF total)	
- Media Volume	374,874 CF each (1,499,496 CF total)	Calc. by JTP/DPW
- Avg. Organic Loading	84 lbs. BOD_5 / 1000 CF / day	
- Vol. Surface Ratio	Plastic media - 27 SF / CF	
- Avg. Hyd. Loading Rate	1.25 gpm / SF (4 towers in use)	125 mgd
- Peak Hyd. Loading Rate	2.0 gpm / SF (3 towers in use)	150 mgd (Firm Peak)
- Min. Hyd. Loading Rate	0.5 gpm / SF (4 towers in use)	50.2 mgd

Table 2-10
Southport AWT Plant - Baseline Design and Loading Criteria - Continued

Treatment Process / Units	Unit Description	Capacity
Tertiary Treatment	**Nitrification**	
ONS Pump Station	6 - 120-inch dia. Open Archimedean Screw Pumps at 44,300 gpm design cap. per pump at 22 rpm and max. 16.56 ft. TDH	255 mgd with 2 of 3 pumps running per side (4 total of 6)
Oxygen Nitrification System	10 - 240' L x 60' W x 15' D Tanks	Currently Operated with Air
	With 4 Stages / Train	
- Average Flow		95 mgd (Avg. Daily)
- Peak Hourly Flow		120 mgd (Peak Hourly)
- Peak Hourly Flow	With Filter Backwash	131 mgd (Peak Hourly)
- Design Avg. BOD5 Load	33.9 lbs. BOD_5 / 1000 CF	
- Design Peak BOD5	63.3 lbs. BOD_5 / 1000 CF	
- Design Avg. NH3 Load	6.7 lbs. NH_3 / 1000 CF	
- Design Peak NH3 Load	10.6 lbs. NH_3 / 1000 CF	
- MLVSS Range	2600 - 4000 mg/L	
- Mean Cell Res. Time	13 days	
- Oxygen Generation	Cryogenic	
- Cryo O_2 Capacity	140 tons per day	Cryogenic off line
- Liquid O_2 (LOX) Storage	800 tons w/ 175 tpd vaporization cap.	LOX off line
ONS - Final Clarifiers	10 - 245' L x 90' W x 14.75' D Rectangular Clarifiers with sludge removal by traveling bridge siphon collectors	
- Average Flow	At 431 gpd / SF surface overflow rate	95 mgd (Avg. Daily)
- Peak Hourly Flow	At 549 gpd / SF surface overflow rate	120 mgd (Peak Hourly)
- Peak Hourly Flow	At 800 gpd / SF surface overflow rate	176 mgd (Peak Hourly)
Air Nitrification System	8 Trains of 4 Tanks - 188' L x 30' W x 15' D	
- Average Flow	Nitrification Mode	30 mgd (Avg. Daily)
- Peak Hourly Flow		30 mgd (Peak Hourly)
- Design Avg. BOD_5 Load	17.4 lbs. BOD_5 / 1000 CF	
- Design Peak BOD_5 Load	31.77 lbs. BOD_5 / 1000 CF	
- Design Avg. NH_3 Load	3.3 lbs. NH_3 / 1000 CF	
- Design Peak NH_3 Load	5.32 lbs. NH_3 / 1000 CF	
ANS - Final Clarifiers	8 - 100' Diameter	
- Average Flow	At 477 gpd / SF surface overflow rate	30 mgd (Avg. Daily)
- Peak Flow	At 796 gpd / SF surface overflow rate	50 mgd (Peak Hourly)
	Peak hourly same as design avg. flow	30 mgd (Peak Hourly)
Intermediate Pump Station (ANS effl. to ONS Effl.)	6,900 CF Wet Well Vol. or 51,612 gallons	Detention Time of 2.5 minutes at 30 mgd
	3 - 15 mgd Single Stage Axial Flow Variable Speed Pumps rated at 25 ft. TDH at 750 rpm	30 mgd (Firm Peak)

Table 2-10
Southport AWT Plant - Baseline Design and Loading Criteria - Continued

Treatment Process / Units	Unit Description	Capacity
Tertiary Treatment	**Effluent Filtration**	
Effluent Filters	12 - Mixed Media (Anthracite Coal and Sand) Filters with 2 cells per filter	
- Dimensions per Filter Cell	61 ft. L x 15.25 ft. W with 20-inch anthracite coal, 7 inch sand, and 12 inch gravel layers	Coal Layer Missing
- Surface Area per Cell	930 SF	2 Cells per Filter
- Total Surface Area	22,320 SF	For all 24 Filter Cells
- Average Flow	At 4.58 gpm / SF (11 Filters)	135 mgd (125 mgd Avg. Flow plus 10 mgd washwater recycle)
- Peak Flow	At 5.46 gpm / SF (11 Filters)	160 mgd (150 mgd Avg. Flow plus 10 mgd washwater) recycle)
- Peak Flow	At 5.0 gpm / SF (11 Filters)	147.4 mgd (Peak Hourly)
Effluent Disinfection	4 - 110' L x 25' W x 16' SWD Ozone Contact Tanks with 4 stage over and under baffling	Ozone off line with temp. Liquid NaOCl Bleach disinfection initiated in 1995, sodium bisulphite used for dechlorination.
- Contact Tank Vol. each	44,000 CF or 329,120 gallons	
- Contact Tanks Volume	176,000 CF or 1,300,000 gallons	
- Average Flow	Contact Time @ 125 mgd	15 minutes (Peak w/ Chlorine)
- Peak Flow	Contact Time @ 160 mgd	11.7 minutes (Peak w/ Ozone)
Effluent Pumping Station (diesel engine power supply)	34,650 CF Wet Well Volume or 259,200 gallons	Detention time of 3.0 min. at 125 mgd and 1.15 min. at 325 mgd
	7 - 54.2 mgd/61.2 mgd Double Stage Axial Flow Pumps with variable speed rated at 37,650 gpm at 290 rpm, and 42,500 gpm at 300 rpm	325 mgd (Firm Peak - 6 of 7 pumps running at 290 rpm), 428 mgd (Peak with all pumps running at maximum speed of 300 rpm)
	1 - 57.6 mgd Single Stage Axial Flow Submersible Pump with maximum speed rated at 44,000 gpm at 24 ft TDH	486 mgd (Peak with all pumps running at maximum speed)

References:

1.) "Preliminary Assessment of Wet Weather Improvements for Belmont AWT Facility (Phase II)," WREP (May 1998)
2.) “A Guide to the Southport Advanced Wastewater Treatment Facility,” Indianapolis DPW bulletin (January 1984 approx.)
3.) “Task 1 Report - Review of Existing Belmont and Southport AWT Facilities, " WREP (February 2001)
4.) “Recommended Standards for Sewage Works,” 1997 Edition.
5.) Based on observations made by WREP staff.
6.) Comment: Due to shallow depth, primary clarifiers can barely handle 140 mgd.
7.) “Operator's Guide" (1987)
8.) 1977 Design Summary for the Southport AWT Plant by Reid, Quebe, Allison, Wilcox & Associates, Inc.
9.) Design Drawings for the Headworks Screw Pump Replacement Project

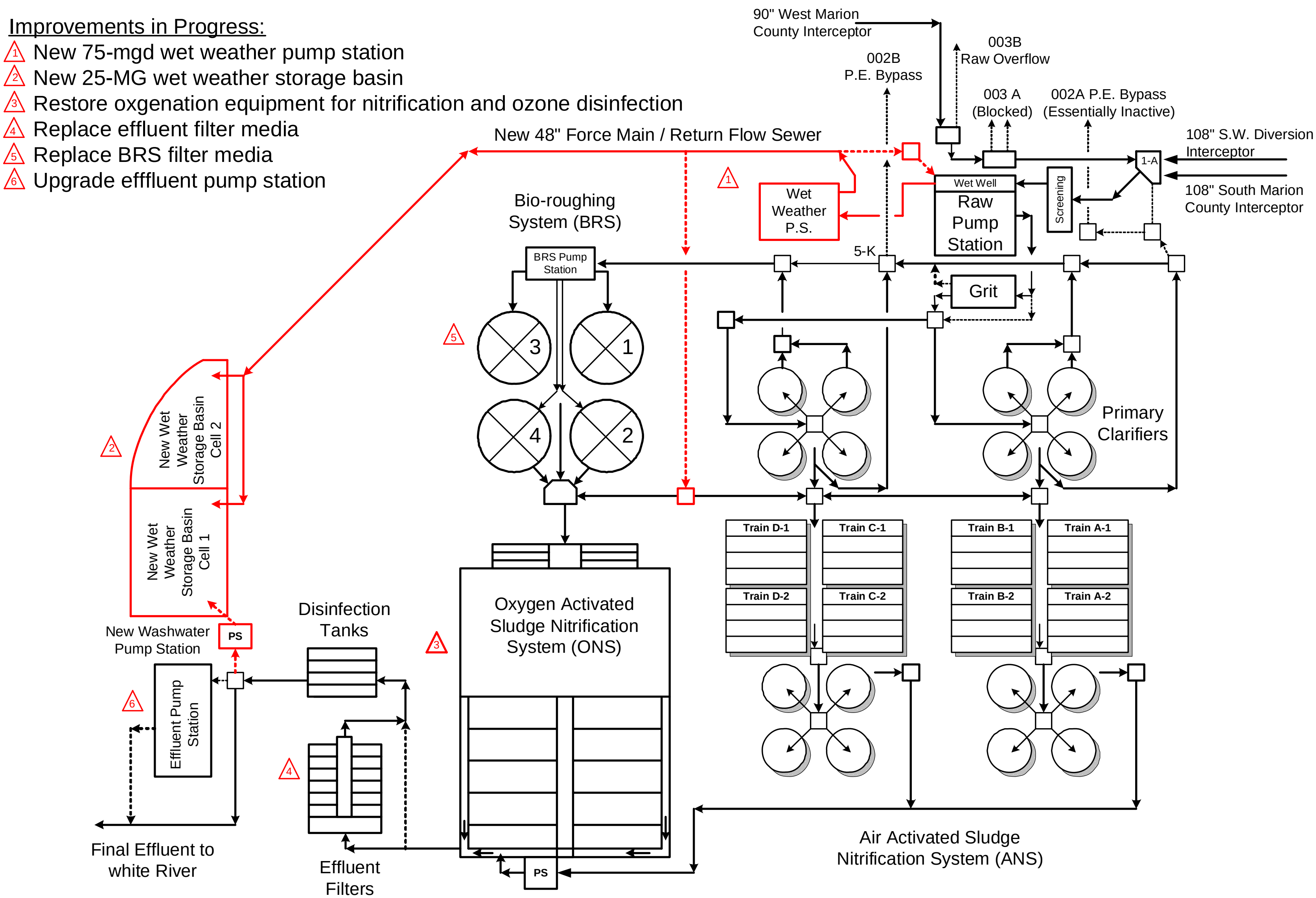

Figure 2-72
Southport AWT Plant Process Flow Schematic

Filtered effluent flows by gravity to four contact tanks for disinfection during the April-October recreational season before being discharged to White River. Sodium hypochlorite and sodium bisulfite are used for effluent chlorination and dechlorination, respectively. Ozone disinfection will be resumed upon completion of a project to upgrade the oxygen and ozone generation equipment. The disinfection process reduces the concentration of bacteria in the treatment plant effluent.

2.6.2.5 Southport Effluent Pumping

The Southport AWT plant was constructed in an area subject to occasional flooding. Accordingly, an earthen dike and floodwall system was constructed around the facility to protect it from flooding. The plant is also protected from high groundwater levels by a moat located inside several sections of the dike. These provisions include a high capacity effluent pumping station that is occasionally needed to pump treated effluent to the White River during times when discharge by gravity is not possible.

2.7 CSO Impacts on Water Quality

This section describes systemwide CSO impacts on water quality. It summarizes the *E. coli* bacteria, biochemical oxygen demand and total suspended solids sources along the White River in the combined sewer area, and presents a comparison with its various tributaries. Analyses are based on the *E. coli* bacteria information presented in the "White River TMDL Study*"* (IDEM, December 2003). CSO discharges consist of mixtures of domestic sewage, industrial and commercial wastewater, and storm runoff. CSOs often contain high levels of suspended solids, pathogens, toxic pollutants, floatables nutrients, oil and grease, and other pollutants. (U.S. EPA, 2001).

2.7.1 Pollutant Loads to the White River and Tributaries

2.7.1.1 *E. coli* Bacteria

Table 2-11 and **Figure 2-73** present the annual *E. coli* bacteria load discharged from CSOs into the White River and its tributaries. This information comes from the White River, Fall Creek and Pleasant Run TMDL studies (December 2003). The White River system consists of CSOs that discharge directly into the White River, the four system relief points (008, 117, 118, and 039), and the Primary Effluent (PE) Bypass at the Belmont AWT plant.

The *system relief points* are CSO discharge locations along the interceptor sewers. These system relief points act as regulators for those drainage areas in the Central Sub-Network that are directly connected to the interceptors.

The *Primary Effluent (PE) Bypass* is the wet-weather discharge outfall at the Belmont AWT plant. The Belmont PE Bypass point is the single largest point source of BOD and TSS loads within the city's wastewater treatment system. **Table 2-12** compares average annual PE Bypass volumes to estimated annual overflows at the nine largest CSO outfalls. The PE Bypass overflow estimate is based on measured data from 2001 through 2002. The CSO values are based on estimated CSO duration and overflow volumes reported in the city's Discharge Monitoring Reports for the same period. The PE Bypass at the Belmont AWT plant is the single largest discharge point for wet-weather flows. Because it is technically not part of the combined sewer network, the PE Bypass was not considered a "combined sewer overflow" during the 2003 TMDL study. However, the city is addressing the PE Bypass contribution to pollution in the White River, as described in Section 7 of this long-term control plan.

Table 2-11
***E. coli* Bacteria from CSO Sources**

Watershed	Annual CSO *E. Coli* Load (cfu)
Fall Creek CSO	4.02E+16
Pleasant Run CSO	1.51E+16
Pogues Run CSO	4.67E+16
Eagle Creek CSO	2.05E+15
White River CSO & System Relief	5.23E+16
Full CSO System	1.56E+17

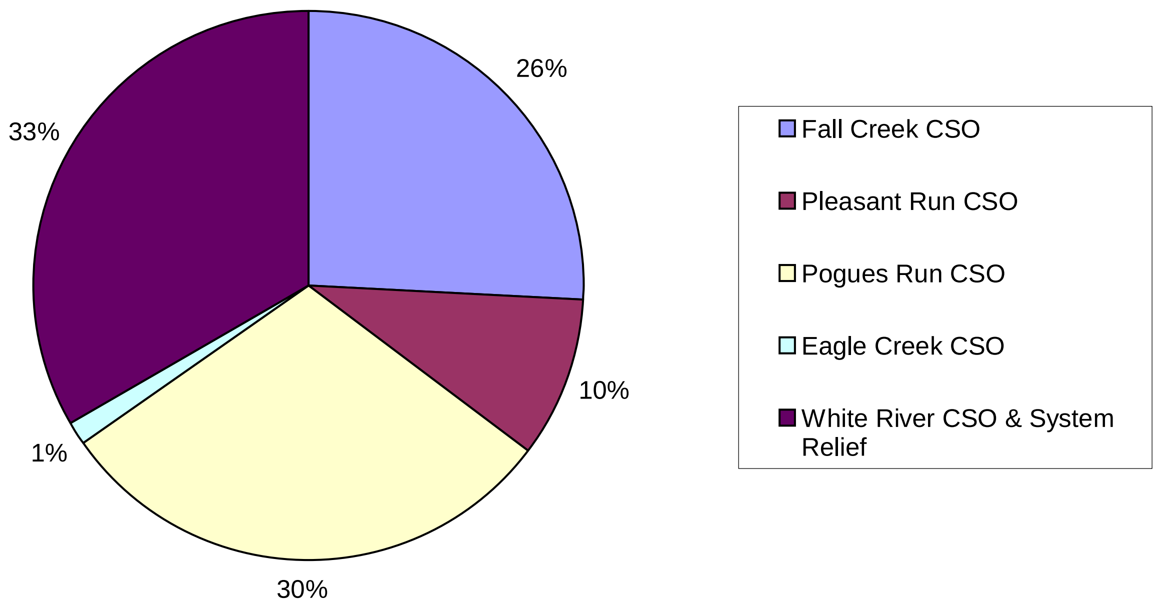

Figure 2-73
Average Annual *E. coli* Bacteria Load (cfu/yr) from CSO Sources
Total Load = 156,000 Trillion cfu/year

Table 2-12
Largest Overflow Points (Ranked by Average Annual Overflow Volume)
(*Outfall close to or associated with Belmont AWT Plant)

Outfall Number	Waterbody	Est. Annual Overflow Volume (MG per Year)	
		2001	2002
P.E. Bypass (007)*	White River	902	1768
CSO 008*	White River	695	1376
CSO 117*	White River	391	412
CSO 034	Pogues Run	375	284
CSO 051	Fall Creek	360	321
CSO 128	Pogues Run	299	307
CSO 062	Fall Creek	273	243
CSO 039	White River	240	270
CSO 115	Pogues Run	223	227
CSO 065	Fall Creek	183	195

Note: P.E. Bypass (007) and CSO 008 volumes are from the 2001 and 2002 Monthly Report of Operations (MRO) data submitted to IDEM. All other CSO volumes are from 2001 and 2002 CSO Discharge Monitoring Reports (DMR) submitted to IDEM.

2.7.1.2 Biochemical Oxygen Demand (BOD)

Figure 2-74 presents the location of the 10 largest CSO BOD load discharge points throughout the combined sewer area. **Table 2-13** summarizes the BOD load estimates for these outfalls. Three of the 10 discharge points are located along the White River, four along Fall Creek, and three on Pogues Run. The three system relief points along the White River are large CSO BOD load discharge points. CSO outfalls 061 and 063 are relief points for the upper North Fall Creek interceptor. CSOs 051 and 062 are outfalls located along the South Fall Creek interceptor serving the two largest combined sewer drainage areas in the South Fall Creek area. In Pogues Run, CSO 115 is located along the downstream portions of the interceptor that serves most of the Pogues Run system, including the downtown area. CSO 115 functions as the system relief point for the Pogues Run interceptor, which explains the greater CSO volumes and pollutant loads.

2.7.1.3 Total Suspended Solids (TSS)

Figure 2-75 shows the location of the 10 largest CSO TSS load outfalls throughout the combined sewer area. **Table 2-14** summarizes the TSS load estimates for these CSO outfalls. As indicated, five of the 10 discharge points are located along Fall Creek and three in Pogues Run. The other two discharge points are the system relief points discharging to the White River. With two exceptions (CSO 099 and CSO 117), all the CSO outfalls with the largest BOD loadings also discharge the largest TSS loads. Based on the TSS load estimates, CSO 065 and CSO 128 are among the 10 largest discharge points. All but one of the system relief points (CSO 117) are among the largest TSS load discharge points.

The PE Bypass at the Belmont AWT plant is the largest wet-weather contributor of BOD and TSS in the CSO system. Furthermore, it discharges almost twice the BOD load and nearly half the TSS load of the next nine largest CSO contributors combined.

2.7.2 Impact of CSO Discharges on Marion County Streams

According to a 1996 *E. coli* bacteria study performed by the city, exceedances of the daily maximum *E. coli* bacteria standard occur approximately 180 days a year at the upstream county line. An analysis of the *E. coli* bacteria concentration in stormwater and CSOs concluded that:

- CSOs discharge approximately 60 times a year and their impact on water quality lasts for about three days (approximately 180 days per year) after the overflow event.
- Stormwater discharges that lead to a significant water quality impact occur at least 60 times a year, but their impact on water quality lasts two days after the event, or approximately 120 days per year.
- Since both stormwater and CSO discharges are caused by rainfall, the discharges often occur simultaneously. The impact of CSO discharges lasts longer because of the higher bacteria counts in CSOs.

Table 2-13
Ten Largest CSO-Related BOD Load Discharge Points
(Excludes 007 PE Bypass: est. 1,177,000 lbs/year BOD load)

Rank	CSO	Tributary	Range of BOD Load (lbs/yr)
1	CSO 008	White River	620,000 - 1,458,000
2	CSO 118	White River	307,400 - 430,600
3	CSO 115	Pogues Run	197,500 - 275,000
4	CSO 034	Pogues Run	109,700 - 152,700
5	CSO 051	Fall Creek	106,100 - 147,800
6	CSO 061	Fall Creek	85,400 - 118,900
7	CSO 099	Pogues Run	83,700 - 115,900
8	CSO 063	Fall Creek	77,600 - 107,900
9	CSO 117	White River	65,600 - 89,200
10	CSO 062	Fall Creek	59,200 - 82,400

Source: 1997-2004 MRO data for CSO 008 and PE Bypass (007), 1950-2003 NetSTORM simulation for all other CSOs.

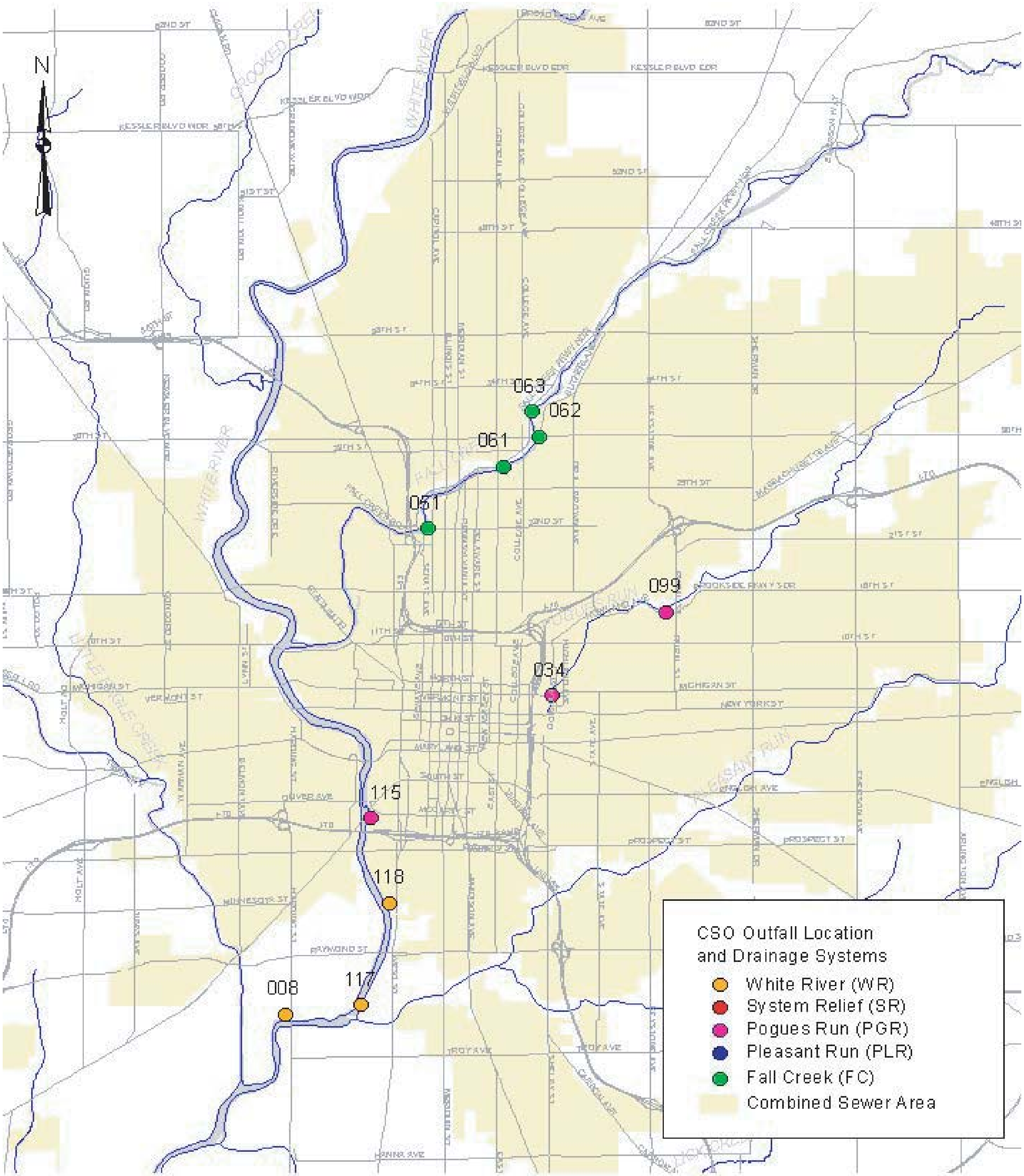

Figure 2-74: Ten Largest CSO BOD Load Discharge Points (excludes 007 PE Bypass)

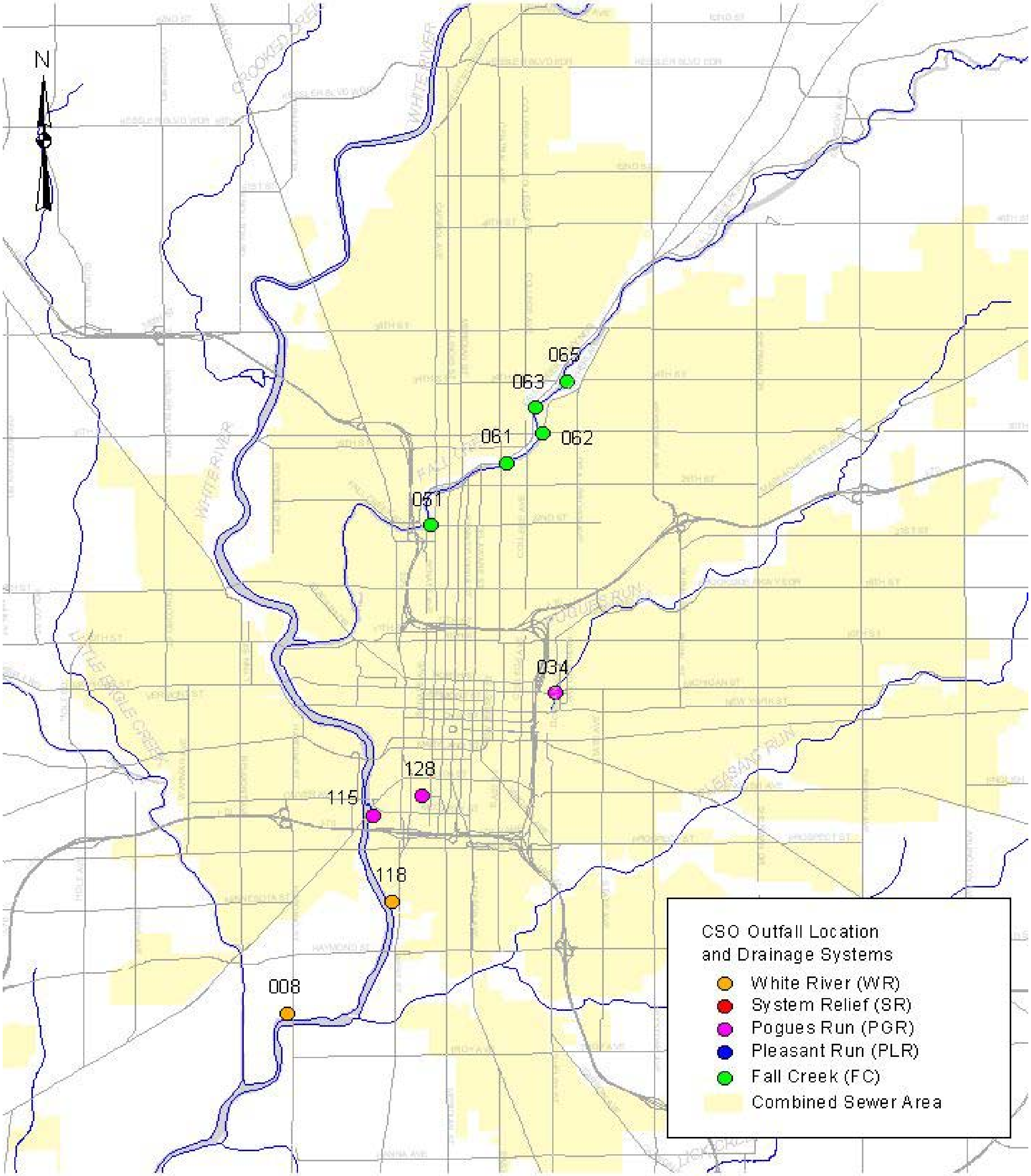

Figure 2-75
Ten Largest CSO TSS Load Discharge Points (excludes 007 PE Bypass)

Table 2-14
Ten Largest CSO-related TSS Load Discharge Points
(Excludes 007 PE Bypass: est. 1,279,000 lbs/year TSS load)

Rank	CSO	Tributary	Range of TSS Load (lbs/yr)
1	CSO 008	White River	976,000 - 2,639,000
2	CSO 118	White River	631,900 - 858,800
3	CSO 115	Pogues Run	538,900 - 731,200
4	CSO 061	Fall Creek	425,800 - 576,900
5	CSO 051	Fall Creek	390,600 - 529,500
6	CSO 063	Fall Creek	241,600 - 327,600
7	CSO 034	Pogues Run	214,800 - 291,700
8	CSO 062	Fall Creek	180,400 - 244,700
9	CSO 065	Fall Creek	174,100 - 236,100
10	CSO 128	Pogues Run	169,600 - 229,900

Source: 1997-2001 MRO data for CSO 008 and PE Bypass (007), 1950-2003 NetSTORM simulation for all other CSOs.

Previous analysis concluded that reducing CSO discharges would reduce the days of exceedances of the *E. coli* daily maximum bacteria standard (235 cfu/100 mL) by one day for every systemwide CSO event eliminated. Recent studies have examined the problem in more detail. The more detailed analysis was possible because of additional instream data and several studies, including TMDL studies on White River, Fall Creek, Pleasant Run, and Bean Creek that required a more detailed review of available water quality data. The Office of Environmental Services, Marion County Health Department and IDEM instream *E. coli* data from the years 2000, 2001, and some of 2002 were used for all sampling stations within the CSO area. These data included information on tributaries as well as White River.

Frequency distribution plots were developed by compiling all the data from the sampling stations along each stream. These plots are shown in **Figures 2-76** through **2-81**. The data were plotted from low to high to demonstrate the percent of time *E. coli* values achieved a certain level in the stream during the sampling period. The plots illustrate the state's 235 cfu/100 mL recreational standard as well as an *E. coli* benchmark of 2000 cfu/100 mL. (The 2000 cfu/100 mL benchmark was analyzed for informational purposes only, since it is not a regulatory threshold or standard.

The percent of time that sampling results are linked to CSOs and stormwater is based on the frequency of stormwater and CSO discharges and the travel time for the specific stream. For example, Pleasant Run has stormwater discharges approximately 60 times per year and an impact time of 24 hours. Therefore, stormwater impacts occur 60 days, or 16 percent of the year. The percent of time that stormwater discharges, but not CSOs, are impacting *E. coli* levels is illustrated within the area marked "stormwater influence." The most frequent CSOs discharge 45 times per year on Pleasant Run, or 45 days (12 percent) of the year. Both stormwater and CSOs are impacting the stream for samples that fall within the area marking the "beginning of CSO influence." CSOs are the primary factor affecting in-stream water quality for samples labeled "CSO dominant." These results, and other aspects of CSO impacts on water quality are discussed in more detail in the January 7, 2003, "Presentation Supplement for CSO Control Technology Evaluation" and the May 2003 "Supplemental Information to the CSO Control Technology Evaluation Meeting."

Figure 2-82 illustrates the city's analysis of downstream CSO impacts based upon water quality modeling of the White River. These results indicate that Indianapolis CSO discharges caused by a 1-year storm in Marion County may contribute to exceedances of the *E. coli* daily maximum bacteria standard to a downstream point somewhere between Newberry and Petersburg (a distance of approximately 140 river-miles from the Belmont AWT plant).

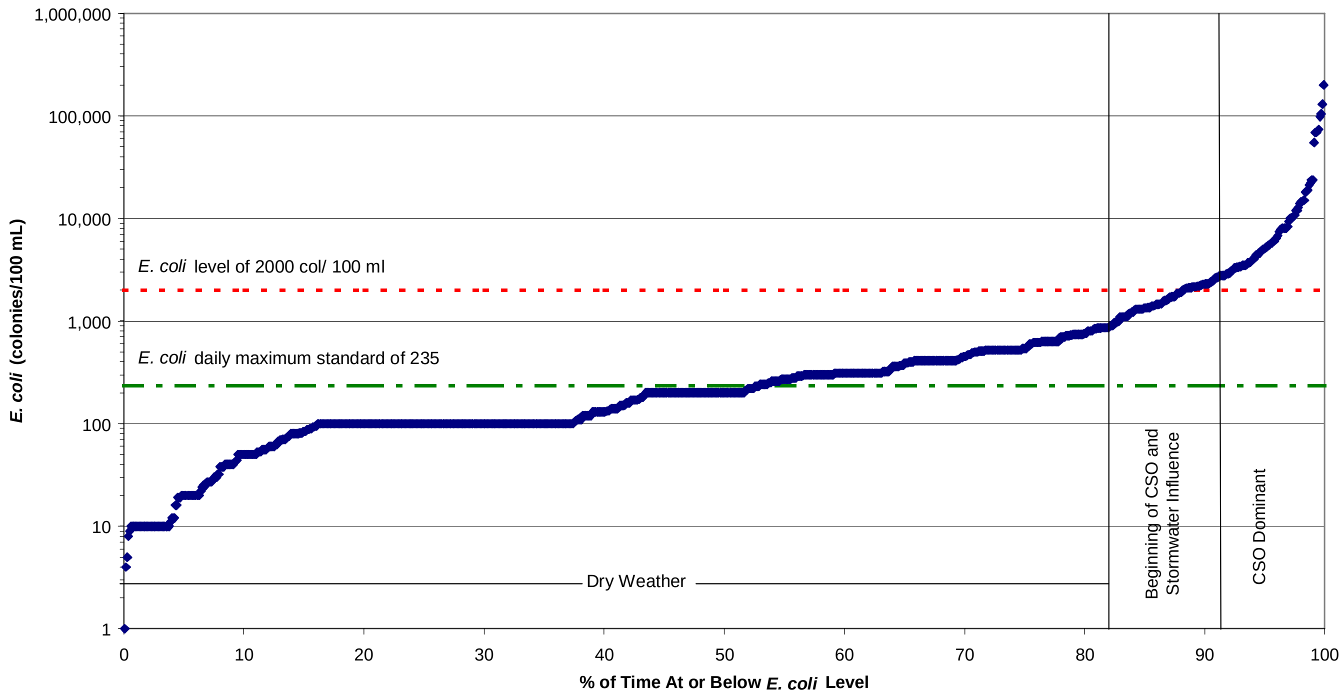

Figure 2-76
Monitored Instream *E. coli* Bacteria Concentrations Frequency Curve
White River in Indianapolis - January 2000 to December 2001

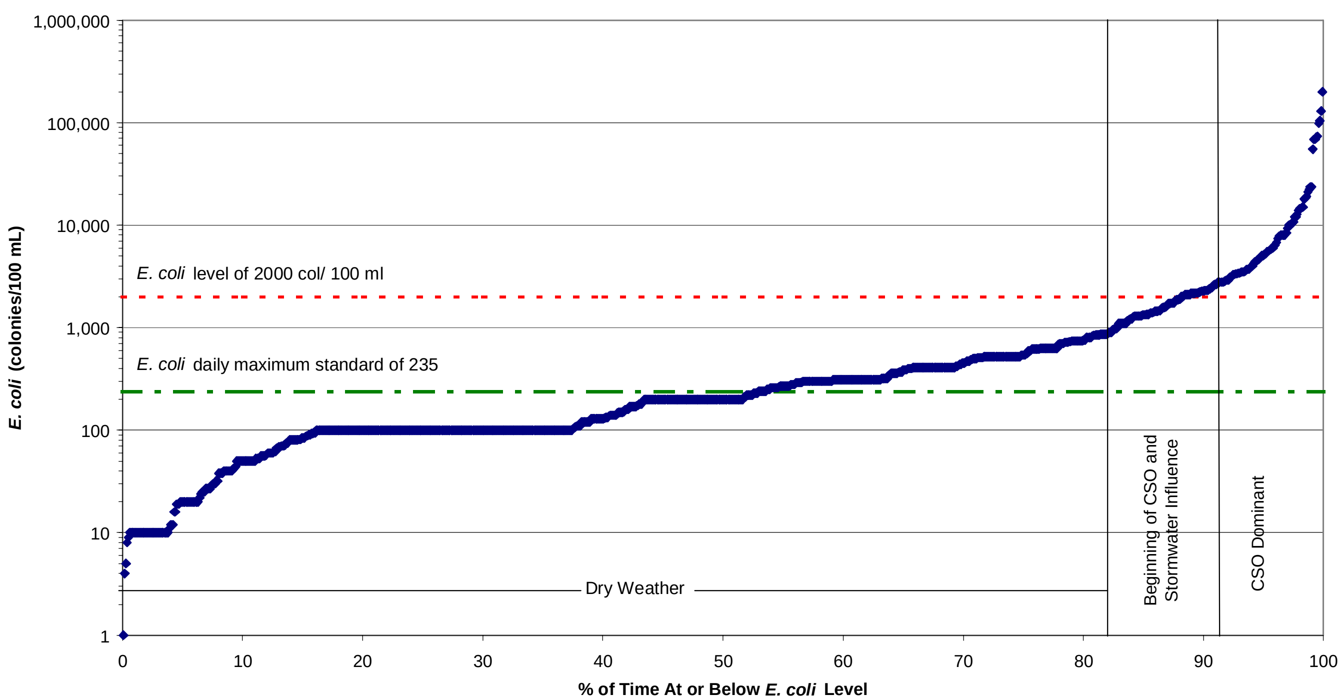

Figure 2-77
Monitored Instream Bacteria Concentrations Frequency Curve
Fall Creek - January 2000 to July 2002

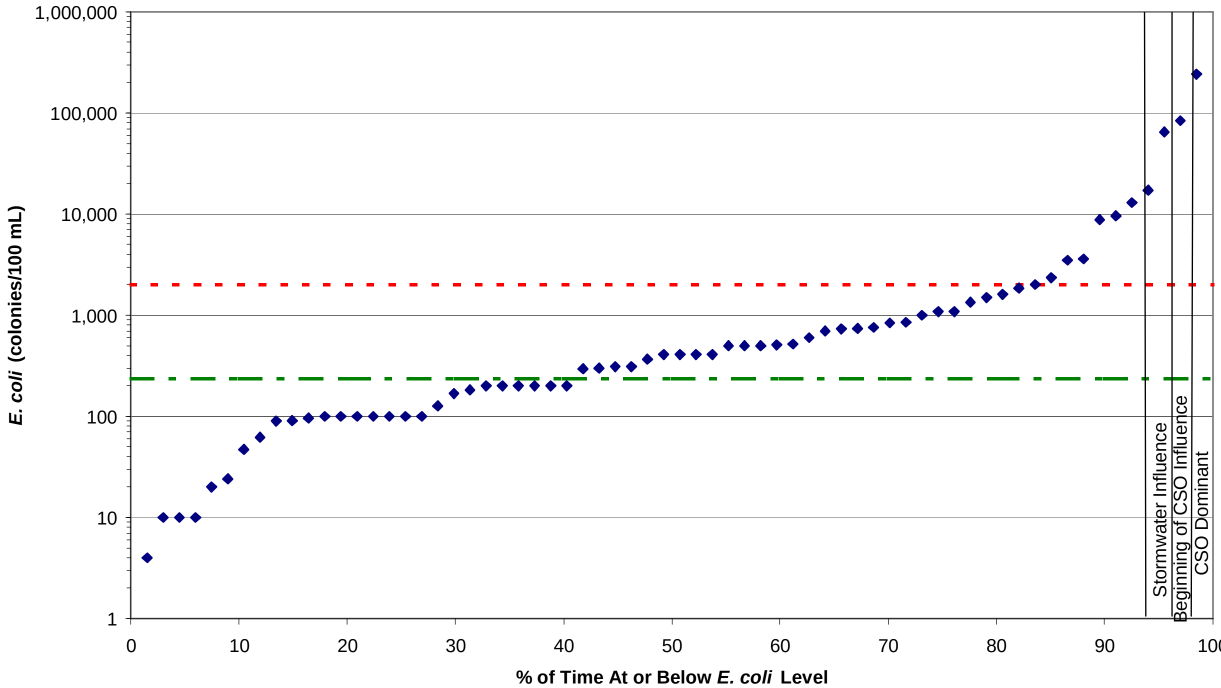

Figure 2-78
Monitored Instream Bacteria Concentrations Frequency Curve
Eagle Creek - January 2000 to December 2001

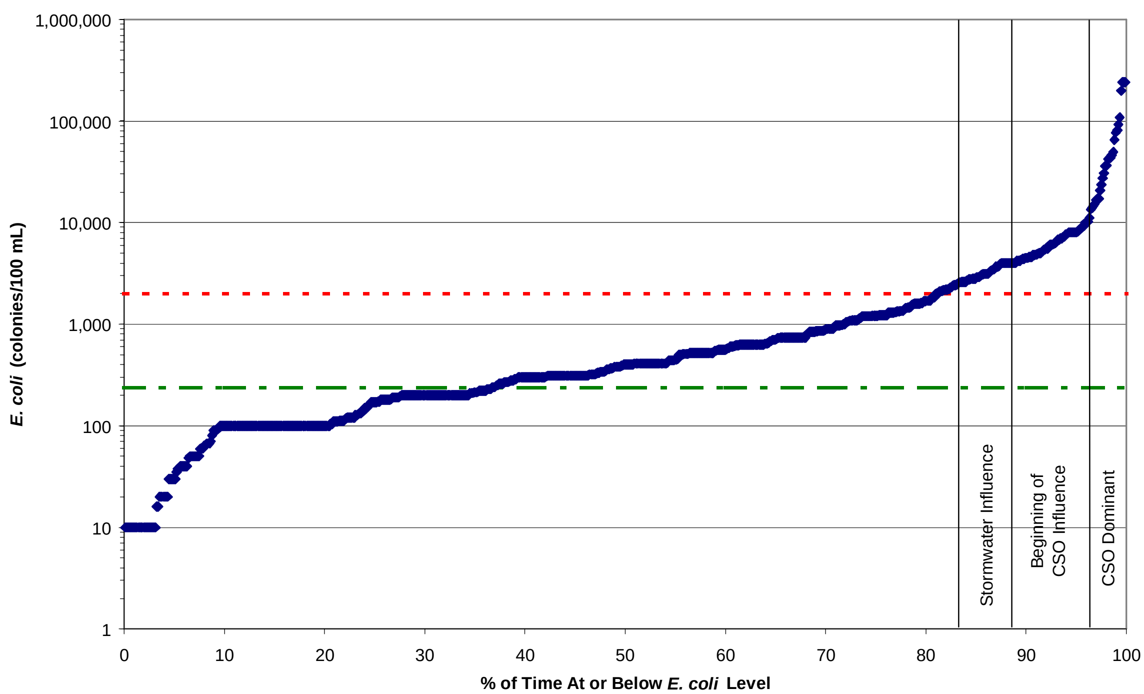

Figure 2-79
Monitored Instream Bacteria Concentrations Frequency Curve
Pleasant Run- January 2000 to July 2002

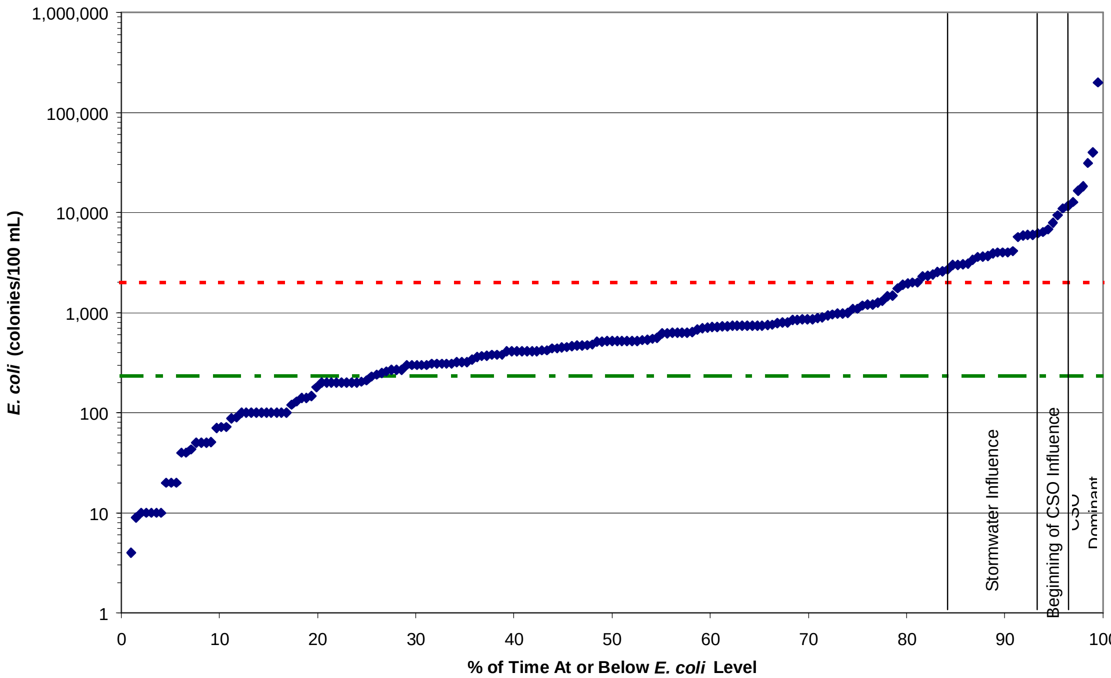

Figure 2-80
Monitored Instream Bacteria Concentrations Frequency Curve
Bean Creek - January 2000 to July 2002

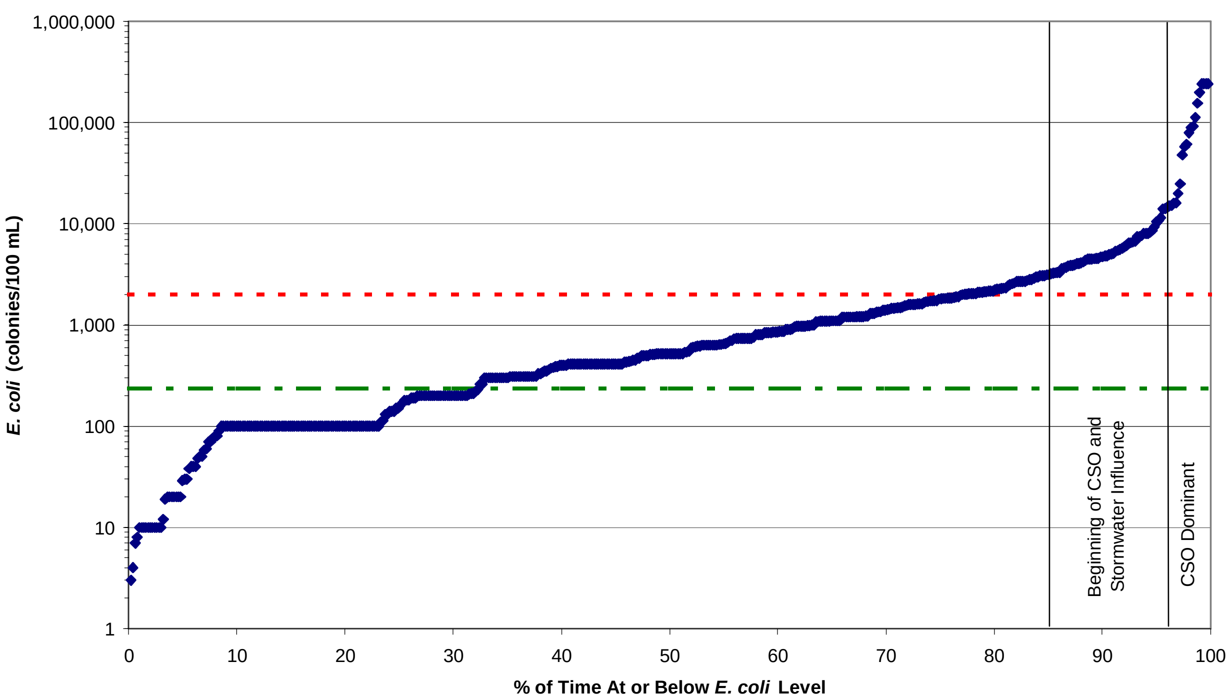

Figure 2-81
Monitored Instream Bacteria Concentrations
Pogues Run - January 2000 to December 2001

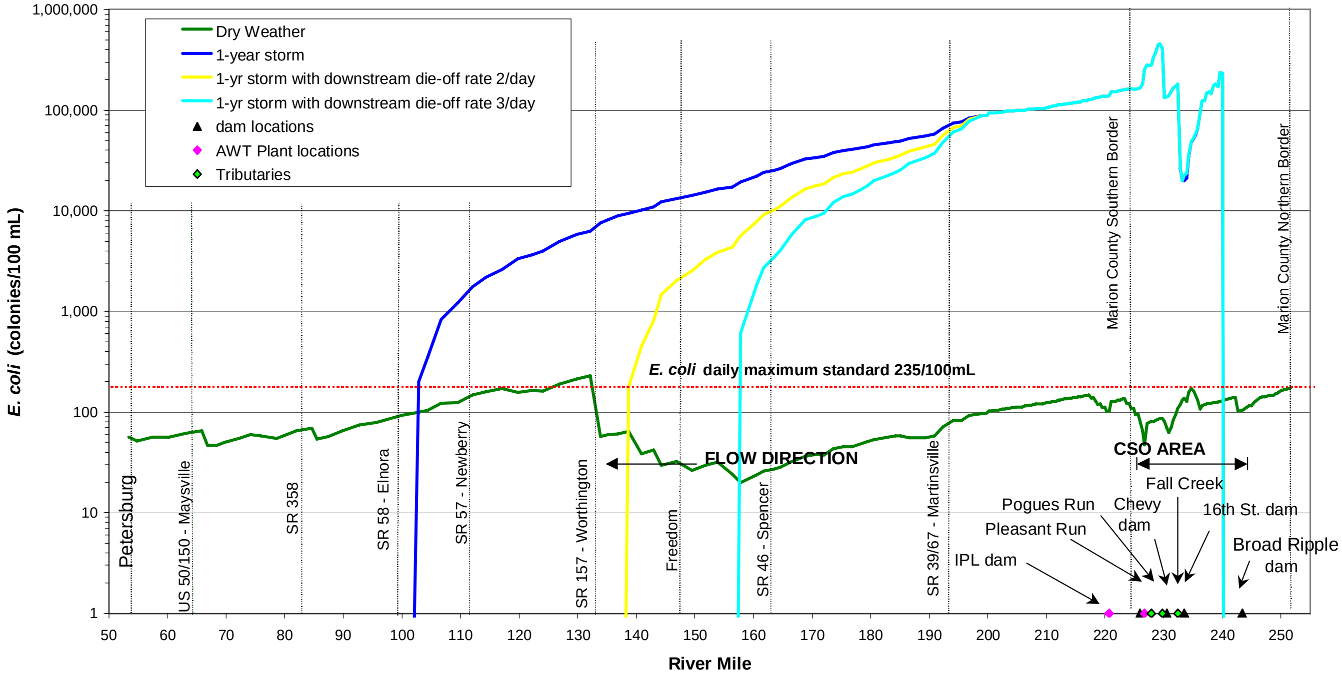

Figure 2-82
Maximum Predicted Bacteria Concentrations Caused by CSOs in the White River for Various Scenarios - Huff 50th Percentile 1-Year, 6-Hour Event (Excludes Background and Non-point Source Contributions)

Instream water quality data collected by the City of Indianapolis and data reported by IDEM appear to support the modeling results presented in **Figure 2-82**. **Figure 2-83** shows sampled *E. coli* bacteria levels downstream from Marion County at Waverly (river-mile 211), Centerton (river-mile 199), and Martinsville (river-mile 190). These data show that *E. coli* conditions improve from 30 percent compliance at Waverly to 45 percent compliance at Centerton and 64 percent compliance at Martinsville. It is important to note that there are multiple potential sources for bacteria loads in White River both upstream and downstream of Marion County. These sources also contribute to non-attainment of water quality standards downstream of Indianapolis.

2.8 Non-CSO Pollution Sources in the Watershed

In addition to CSOs, other factors contribute to water quality problems in the White River and its tributaries. This section will examine those other contributing factors and discuss their impacts on the river system. The focus is on non-CSO sources that contribute to poor water quality in the White River system, including lack of dissolved oxygen, high *E. coli* bacteria, and poor aesthetics such as solids, floatables, and odors. Analyses are based on the *E. coli* bacteria information presented in the *White River TMDL Study* (IDEM, December 2003), *Fall Creek TMDL Study* (IDEM, December 2003), and the *Pleasant Run and Bean Creek TMDL Study* (IDEM, December 2003).

The pollution concerns in the White River system are varied and dynamic. Significant non-CSO pollutant sources to the White River system include the following:

- Stormwater
- Failing septic systems
- Illicit sanitary connections to storm sewers
- Urbanization
- Domestic animals and wildlife
- Sediment oxygen demand
- Belmont and Southport AWT plant discharges
- Pollutant sources upstream and downstream of Marion County

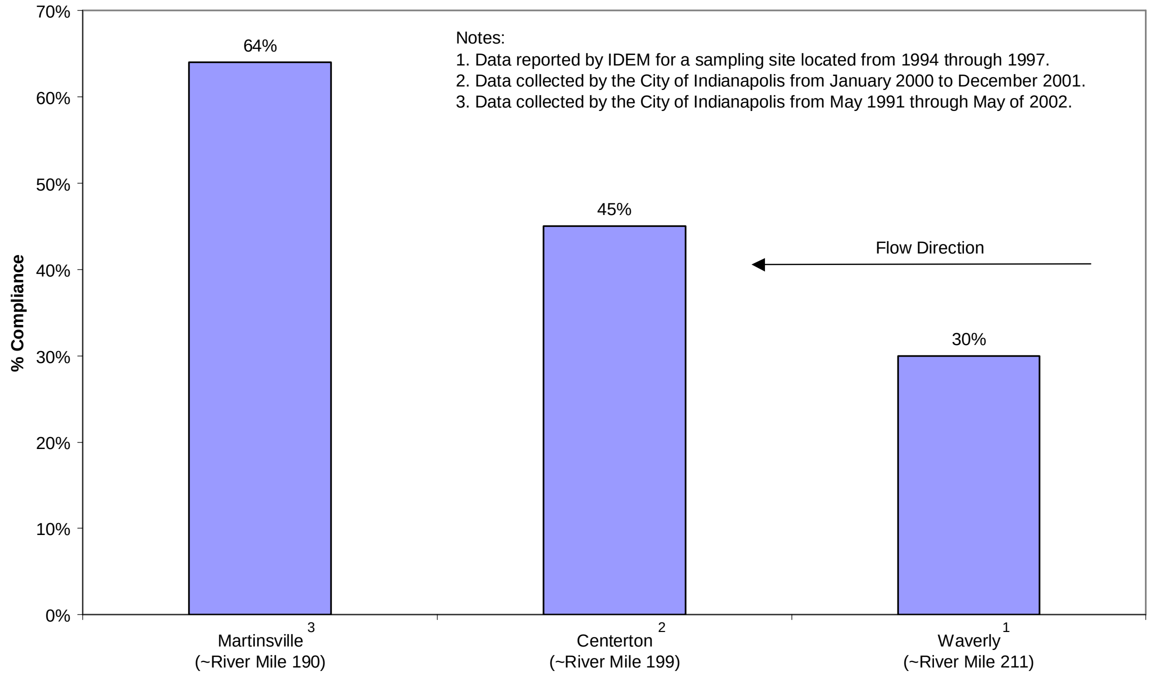

Figure 2-83
Percent Compliance with Indiana Single Sample Maximum of *E. coli* Standard on the White River Downstream of Marion County

In addition to these sources, there are three additional factors that can aggravate pollution problems in Indianapolis waterways. They are:

- Dams
- Indianapolis Power & Light heated cooling water discharges
- Water withdrawals for public drinking water

2.8.1 Stormwater

Stormwater often carries *E. coli* bacteria because of loadings from domestic animals, wildlife and agricultural land. **Table 2-15** presents a summary of the annual surface runoff *E. coli* bacteria loadings into White River and its tributaries, based upon water quality modeling. This load contains all sources of *E. coli* bacteria carried by stormwater runoff, including wildlife. **Figure 2-84** shows these same data in a pie chart. The chart shows that sources upstream of Marion County and along the White River north of the CSO area contribute 50 percent of the average annual *E. coli* bacteria load from stormwater sources.

The city, as part of a state permit requirement, collected data on the quality of urban stormwater runoff. Water quality samples were collected at three storm drain outfalls for three storms. The drainage areas to the three storm drains had representative areas of low density residential, commercial, and industrial land use. All samples were above the former U.S. EPA fecal coliform water quality standard of 200 colony forming units (cfu)/100 mL. Bacteriological monitoring confirms that stormwater contributes to high bacteria levels in Indianapolis area waterways. Although controlling CSOs is the most critical factor in improving bacteriological conditions, urban stormwater also contributes to water quality exceedances. Based on bacteriological monitoring results, the city's water quality model estimates stormwater runoff concentrations averaging 5,000 *E. coli* colonies/100 mL in each drainage basin in Indianapolis. The estimate was based on sampling conducted for the city's stormwater permit application, an extensive 18-month bacteriological survey in 1996 and 1997, representative sampling of storm sewers, CSO project-related data, and the city's river monitoring program. Based on existing data and studies in similar communities, relative contributions to in-stream stormwater bacteria concentrations were estimated to equal 1,000 colonies/100 mL from septic systems, 2,000 colonies/100 mL from

Table 2-15
***E. coli* Bacteria from Stormwater Sources**

Watershed	Daily Average Stormwater Load (cfu)	Annual Stormater Load (cfu)
Mud Creek	1.79E+11	6.52E+13
Fall Creek Upstream of the CSO Area	1.24E+12	4.52E+14
Fall Creek CSO Area	3.40E+11	1.24E+14
Fall Creek Total	**1.76E+12**	**6.41E+14**
Pleasant Run Upstream of the CSO Area	2.56E+11	9.34E+13
Pleasant Run CSO Area	4.35E+10	1.59E+13
Pleasant Run Total	**2.99E+11**	**1.09E+14**
White River Upstream of Marion County	7.06E+11	2.58E+14
White River North	4.54E+12	1.66E+15
White River CSO Area -- Includes Pogues Run and Eagle Creek	1.90E+12	6.95E+14
White River South	1.24E+12	4.51E+14
White River & Tributary Total	**1.04E+13**	**3.81E+15**

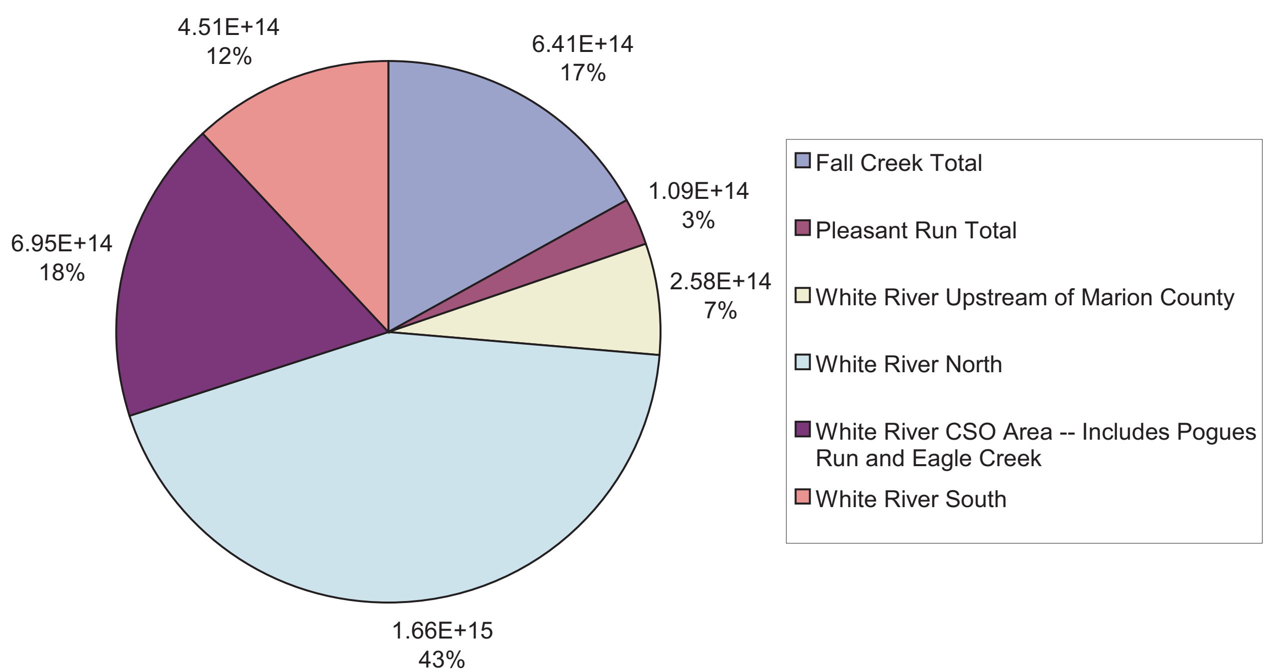

Figure 2-84
Average Annual *E. coli* Bacteria Load (cfu/yr) from Stormwater Sources
Total Load = 3,810 Trillion cfu/year

surface runoff, 1,500 colonies/100 mL from illicit sewer connections, and 500 colonies/100 mL from background sources, such as waterfowl, fish, etc. The sources of bacteria in stormwater are described in greater detail in the text that follows.

2.8.2 Septic Systems

Areas within Marion County that are not served by sanitary sewers are a potential threat to the health, welfare, and environment of the community. In past years, county administrators have allowed developers in unsewered areas to utilize septic systems as a means to handle sanitary waste. While some septic system permits are still issued each year, the number of residential septic systems has declined by about 30 percent since 1990, according to the Marion County Health Department. Although septic systems remain a viable disposal option for some rural areas in Indiana, they require suitable soils, geology, and enough space to prevent the occurrence of health and environmental hazards. Unfortunately, due to rapid development in Marion County, there are very few areas where all the aforementioned criteria can be adequately met. In addition, many older neighborhoods rely on septic systems that are more than 20 years old. Aging septic systems have a greater risk of failure.

When a septic system fails, sewage is forced to the ground surface, resulting in pools of wastewater in residential yards. This sewage can carry a variety of disease-causing bacteria. Residents often construct tiles and other illicit connections to divert sewage and/or laundry and sink water to ditches and streams. Failing systems also can transport contaminants into groundwater and nearby drinking water wells. Stormwater also can carry septic system contaminants to streams.

While CSOs contribute significant concentrations of *E. coli* into Marion County streams, they are episodic and intermittent in nature. Failing septic systems are a more persistent problem throughout the year. Because failed septic systems are more widespread and persistent than CSOs, septic systems on their own lead to a significant number of days of bacteria violation in Indianapolis, particularly during dry weather. **Table 2-16** summarizes the estimated failed septic *E. coli* bacteria loadings into the White River and its tributaries. **Figure 2-85** illustrates the same data proportionally, showing that failing septic systems along the White River upstream of the CSO area contribute 44 percent of the average annual *E. coli* bacteria load from septic sources. Failing septic systems along Fall Creek and Pleasant Run each contribute another 21 percent of the average annual load.

Table 2-16
***E. coli* Bacteria from Failed Septic Sources**

Watershed	Estimated Failing Septic Daily Load (cfu)	Estimated Failing Septic Annual Load (cfu)
Mud Creek	4.11E+09	1.50E+12
Fall Creek Upstream of the CSO Area	4.25E+10	1.55E+13
Fall Creek CSO Area	0.00E+00	0.00E+00
Fall Creek Totals	**4.66E+10**	**1.70E+13**
Pleasant Run Upstream of the CSO Area	5.39E+09	1.97E+12
Pleasant Run CSO Area	4.18E+09	1.53E+12
Pleasant Run Totals	**9.57E+09**	**3.49E+12**
Howland & Johnson Ditch	1.64E+10	5.99E+12
Crooked & Williams Creek	4.17E+10	1.52E+13
White River North	3.91E+10	1.43E+13
Eagle & Guion Creek	2.18E+09	7.96E+11
White River CSO Area -- Includes Pogues Run	2.04E+10	7.44E+12
State Ditch, Buck & Lick Creek	2.16E+10	7.87E+12
White River South	2.57E+10	9.37E+12
White River & Tributary Total	**2.23E+11**	**8.15E+13**

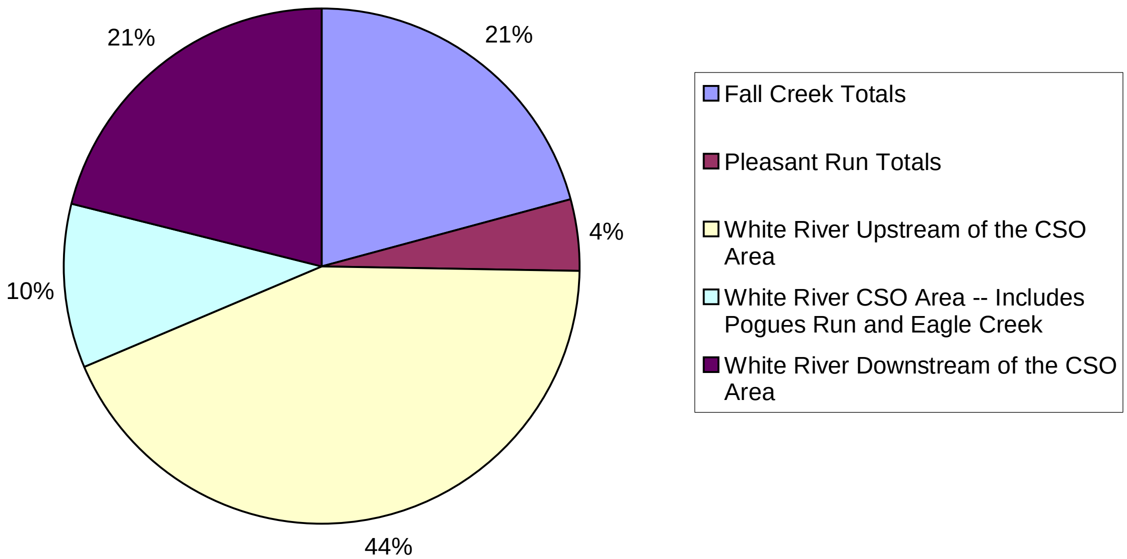

Figure 2-85
Average Annual *E. coli* Bacteria Load (cfu/yr) from Failing Septic Sources
Total Load = 81.5 Trillion cfu/year

2.8.3 Illicit Sanitary Connections to Storm Drains

Stormwater outfalls can carry *E. coli* bacteria from illicit sanitary connections to the stormwater collection system. The City of Indianapolis Fifth Annual Report (2002) for the NPDES stormwater permit (AMEC, 2002) reported that approximately 7.7 percent of the stormwater outfalls sampled contained dry weather flows. This flow is assumed to contain *E. coli* bacteria. **Table 2-17** summarizes the estimated *E. coli* bacteria loadings to Marion County streams from illicit storm sewer connections. **Figure 2-86** illustrates this same data proportionally, showing that Fall Creek contributes 33 percent and Pleasant Run 22 percent of the average annual *E. coli* bacteria load from unpermitted sanitary connections.

The Department of Public Works OES responds to complaints of dry-weather discharges from stormwater outfalls. The MCHD has the legal authority to take enforcement actions for illicit connections. Once dry-weather stormwater discharges are identified and found to be illegal, OES refers them to MCHD to further investigate and take appropriate action against the illegal discharger.

From 1998 to 2002, OES had a dry-weather stormwater outfall screening program as required by Phase I of the NPDES stormwater permit. During this five-year period, OES screened 100 stormwater outfalls greater than 24 inches in diameter during dry weather each year, and sampled any dry weather discharges found. After surveying 500 outfalls, OES had identified approximately 25 illicit connections and referred them to MCHD for further action.

2.8.4 Urbanization

U.S. EPA and states develop biological assessment tools and biological criteria to reflect and interpret the biological integrity goal of the Clean Water Act as the natural (or minimally impacted) condition of the water body. Many factors inhibit the attainment of natural aquatic communities in urban areas: the amount of impervious surface, human activity, and/or the type and extent of hydrologic modifications. Some recent literature suggests the restoration of natural aquatic life communities may not be feasible in small watersheds with heavily urbanized areas. One study found significant impairment of aquatic life where levels of impervious cover in urban areas were in the range of 8 percent to 20 percent (Schuler, 1994). Another found this threshold level is also influenced by other factors such as pollutant loadings, watershed development history, riparian buffers, CSOs, and types of land use (Yoder, 1999). More sensitive aquatic life, such as brook trout, may be unable to survive in watersheds with as little as 1 percent to 2 percent impervious land cover.

Table 2-17
***E coli* Bacteria from Unpermitted Sanitary Connections**

Watershed	Estimated Unpermitted Connection Daily Load (cfu)	Estimated Unpermitted Connection Annual Load (cfu)
Mud Creek	3.03E+07	1.11E+10
Fall Creek Upstream of the CSO Area	9.08E+07	3.32E+10
Fall Creek CSO Area	5.30E+07	1.93E+10
Fall Creek Totals	**1.74E+08**	**6.36E+10**
Pleasant Run Upstream of the CSO Area	5.30E+07	1.93E+10
Pleasant Run CSO Area	6.06E+07	2.21E+10
Pleasant Run Totals	**1.14E+08**	**4.14E+10**
Crooked Creek & Johnson Ditch	6.81E+07	2.49E+10
Williams Creek	3.79E+07	1.38E+10
White River North	1.51E+07	5.53E+09
White River CSO Area -- Includes Pogues Run and Eagle Creek	9.08E+07	3.32E+10
White River South	1.51E+07	5.53E+09
White River & Tributary Total	**5.15E+08**	**1.88E+11**

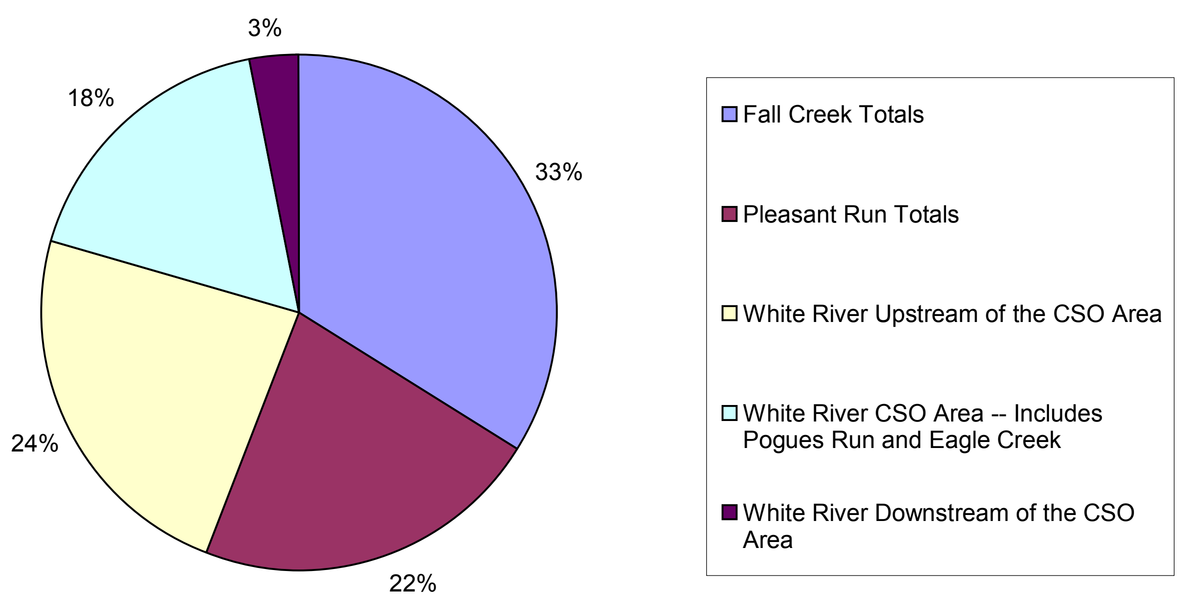

Figure 2-86
Average Annual *E. coli* Bacteria Load (cfu/yr) from Unpermitted Sanitary Sources
Total Load = 0.188 Trillion cfu/year

2.8.5 Domestic Animals and Wildlife

Pets and wildlife that have adapted to an urbanized landscape can be a significant source of bacteria in an urban stream. In recent years, scientists have experimented with bacterial source tracking, a new methodology to determine the sources of fecal bacteria from environmental samples (from human, livestock, or wildlife origins). Both molecular (genotype) and biochemical (phenotype) fecal sourcing methods are under development. DNA fingerprinting has received the greatest publicity, but there are other methods described in scientific literature that show potential.

A number of studies have used fecal sourcing methods to identify the sources of bacteria in a watershed. A study released on October 26, 2000, by the Northern Virginia Regional Commission and Virginia Tech identified not only the sources, but also the *relative contributions* of waterfowl, dogs, humans and wildlife to bacteria pollution in an urbanized watershed. The study used DNA analysis to track sources of waterborne *E. coli* in the Four Mile Run watershed in suburban Washington, D.C., an area that includes the predominantly residential communities of Arlington, Alexandria, Falls Church, and Fairfax County, Virginia. The area does not include any combined sewer systems. Fecal coliform monitoring in the Four Mile Run watershed shows that approximately 50 percent of samples taken since 1990 have exceeded the Virginia state water quality standard for fecal coliform bacteria.

The city estimated *E. coli* bacteria loadings from wildlife sources during its TMDL analysis, performed under contract to IDEM. **Table 2-18** summarizes the estimated *E. coli* bacteria loadings into the White River that are a result of natural biota in the watersheds. **Figure 2-87** illustrates this same data proportionally, showing that 56 percent of the average annual *E. coli* bacteria load is found in White River south of Marion County, with 29 percent coming from White River upstream of Marion County. This load represents wildlife or natural *E. coli* bacteria during dry-weather conditions only. *E. coli* bacteria from wildlife or natural sources that is conveyed to the river by surface runoff is discussed in the stormwater discussion in Section 2.8.1.

2.8.6 Sediment

The organic matter deposited in the sediment on the riverbed creates a sediment oxygen demand (SOD). Though not a direct factor, SOD has an effect on the dissolved oxygen in the river system. The organic matter comes from natural sources, such as leaves, as well as from CSO discharges and the partially treated PE Bypass from the Belmont AWT plant. Once deposited on the riverbed, SOD exerts a dissolved oxygen demand. Better CSO controls will reduce future deposits of new organic matter, and thereby reduce the SOD.

2.8.7 Belmont and Southport AWT Plant Discharges

During dry weather, both the Belmont and Southport AWT plant facilities discharge highly treated effluent that is seasonally disinfected. During wet weather, the Belmont AWT plant often receives inflow that receives primary treatment but exceeds the secondary treatment capacity. Flows that exceed secondary capacity are discharged without disinfection to the White River. Under these wet-weather conditions, the Belmont AWT plant can contribute to exceedances of the dissolved oxygen and bacteria water quality standards.

As a requirement of its NPDES permits, the city monitors effluent at its AWT plants for *E. coli* bacteria during the recreational season, when the effluent must be disinfected. **Table 2-19** summarizes the estimated daily and annual *E. coli* bacteria loadings into the White River from the Belmont and Southport AWT plants. **Figure 2-88** displays this same data graphically, showing that 56 percent of the average annual load comes from the Southport AWT plant and 44 percent from the Belmont AWT plant.

2.8.8 Pollutant Sources Upstream of Marion County

The White River also receives pollutants from sources upstream of Marion County. These upstream sources include major wastewater treatment plants at Carmel, Anderson, Noblesville, and Muncie; urban stormwater runoff; and agricultural sources. To support the White River TMDL Study (IDEM, December 2003), the city's monitoring programs collected sampling data from 2000-2002 for the White River at 96th Street, the upstream border with Hamilton County. The analysis determined that roughly 25 percent of the samples taken at 96th Street were above the 235 cfu/100 mL *E. coli* bacteria standard. The *E. coli* bacteria loads from upstream stormwater sources were presented previously in **Table 2-15** and **Figure 2-84** and from upstream domestic animals and wildlife sources in **Table 2-18** and **Figure 2-87**.

2.8.9 Other Sources of Impacts to the Streams

Dams: Three dams are located on Fall Creek and four dams are on the White River in Marion County. Though not a

Table 2-18
***E. coli* Bacteria from Instream Wildlife**

Watershed	Estimated Instream Wildlife Daily Load (cfu)	Estimated Instream Wildlife Annual Load (cfu)
Mud Creek	2.45E+09	8.93E+11
Fall Creek Upstream of the CSO Area	1.61E+10	5.89E+12
Fall Creek CSO Area	5.81E+10	2.12E+13
Fall Creek Totals	**7.67E+10**	**2.80E+13**
Pleasant Run Upstream of the CSO Area	9.79E+08	3.57E+11
Pleasant Run CSO Area	9.79E+08	3.57E+11
Pleasant Run Totals	**1.96E+09**	**7.14E+11**
White River Upstream of Marion County	3.36E+11	1.23E+14
Crooked Creek	1.19E+10	4.33E+12
White River North	7.31E+10	2.67E+13
White River CSO Area -- Includes Pogues Run and Eagle Creek	9.49E+09	3.46E+12
White River South	6.41E+11	2.34E+14
White River & Tributary Total	**1.15E+12**	**4.20E+14**

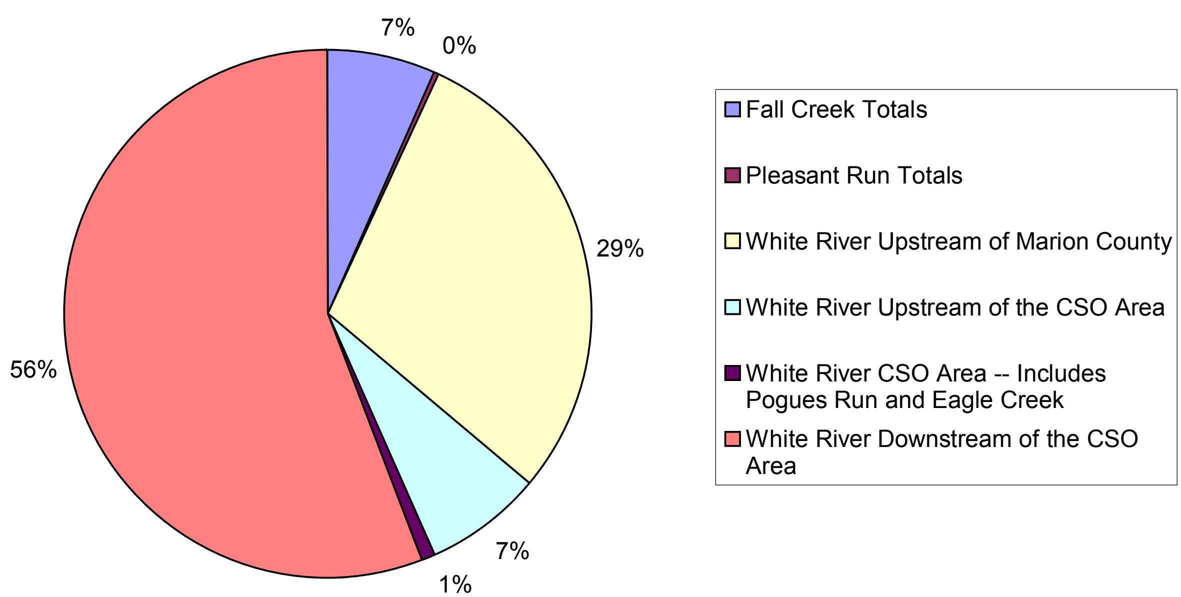

Figure 2-87
Average Annual *E. coli* Bacteria Load (cfu/yr) from Instream Wildlife
Total Load = 420 Trillion cfu/yr

Table 2-19
E. coli Bacteria from AWT Plants' Treated Effluent
(Does not include PE Bypass)

AWT Discharge	Average Daily AWT Load (cfu)	Annual AWT Load (cfu)
Belmont AWT Plant	1.26E+11	4.59E+13
Southport AWT Plant	1.60E+11	5.82E+13

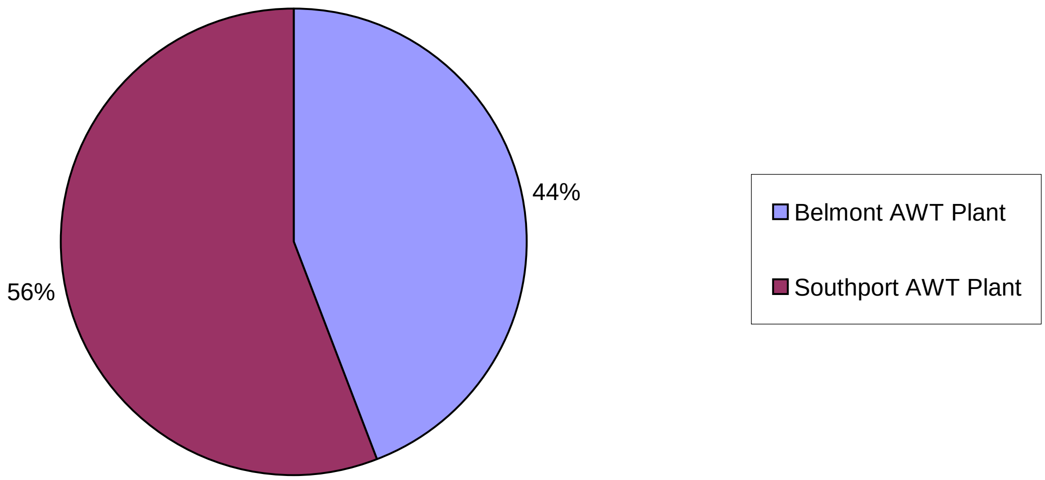

Figure 2-88
Average Annual *E. coli* Bacteria Load (cfu/yr) from AWT Plants' Treated Effluent
(Does not include PE Bypass)
Total Load = 104 Trillion cfu/year

source of pollutants, the dams change river hydraulics and reduce the dissolved oxygen in the river system. By raising the water depth and lowering the velocity of the river, dams increase settling rates (which increases sediment oxygen demand) and reduce natural aeration of the stream. Both factors reduce the dissolved oxygen in the river segments above each dam. After passing over a dam, however, the stream is aerated and dissolved oxygen levels improve significantly.

Water Withdrawals: To supply drinking water for the City of Indianapolis, Indianapolis Water removes water at two locations in Marion County (Broad Ripple dam on the White River and the Keystone dam on Fall Creek) and one location in Hamilton County immediately north of the Marion/Hamilton County line. Normally, in late summer, much of the water in White River and Fall Creek is diverted into the Indianapolis Water facilities, thus reducing the volume of water that flows downstream into lower Fall Creek and White River. The water withdrawal reduces the ability of both Fall Creek and White River to absorb pollutant loads during wet weather.

2.9 Industrial Impacts on Water Quality

Each day, industrial facilities discharge waste into the combined sewer system under the industrial pretreatment permitting program administered by the City of Indianapolis. This wastewater is suitable for treatment at the city's treatment plants; however, it can potentially impact a receiving stream when discharged through a combined sewer outfall during wet weather.

2.9.1 Pollutant Parameters

Within each CSO basin, the city has identified the types of pollutant parameters contained in each industrial facility's NPDES permits. Within Marion County, the conventional pollutants permitted for industrial users are ammonia (NH_3), total suspended solids, BOD, pH, and oil and grease. The non-conventional permitted pollutants include both toxic organic and toxic inorganic pollutants. The toxic organic pollutants consist of the following volatile organic compounds: benzene, ethylbenzene, methylene chloride, and toluene. The toxic inorganic pollutants consist of the following: copper, phenols, arsenic, cyanide, selenium, beryllium, lead, silver, cadmium, mercury, thallium, chromium, nickel and zinc.

2.9.2 Potential Toxicity of Industrial Discharges

The City of Indianapolis has developed an industrial pretreatment program that minimizes possible toxic discharges from industries to the city's sewer collection system, and thus to the downstream CSOs. Since Indianapolis began its pretreatment program in 1985, it has recorded substantial improvement in the quality of industrial wastewater discharged to the municipal sewer system. For example, the discharge of heavy metals has been reduced by up to 90 percent from 1988 levels.

To assist in identification and prioritization of CSO controls, the city conducted additional analysis of the potential toxicity of discharges associated with significant industrial users and corresponding CSO outfalls. This analysis involved two steps: 1) confirming the location of industrial users within the combined sewer system, and 2) analyzing the potential toxic characteristics of industrial user discharges. It is important to recognize that these data are dynamic; each year new industries start up and other industries close. Industries also change and process flows can be increased or decreased by changes in plant operations.

2.9.2.1 Confirm Location of Industrial Users

The city reviewed industrial user permit renewal applications, sewershed maps, pretreatment program inspection reports, the city's GIS database, and other data to confirm the spatial relationships between significant or categorical industrial users and interceptors within the combined sewer area. This analysis was performed to identify CSO outfalls with the greatest potential to discharge industrial wastewater, and those CSOs not potentially discharging industrial wastewater. This analysis yielded an updated list of significant industrial users (SIU) within the combined sewer system, and a map that identifies the location of each significant industrial user within the CSO basins.

2.9.2.2 Confirm Industrial User Discharge Characteristics

The city collected, validated, and evaluated compliance monitoring data to develop a system that would rank the CSOs based on potential presence of toxins in the effluent of SIUs. For purposes of this U.S EPA/IDEM-approved analysis, the city assumed that potential industrial toxic discharges into receiving streams would be associated with the first CSO outfall downstream from the industrial user. In reality, multiple CSO outfalls are associated with a single industrial user's discharges. However, for purposes of prioritizing CSO controls, the city, IDEM and U.S EPA agreed to make an assumption that 100 percent of the potential toxic impacts would be associated with the first outfall downstream of the industrial user. It is important to emphasize that this analysis is based on a theoretical approach, and not on actual monitoring of the toxic constituents of CSO discharges.

The discharge characteristics analysis will be particularly valuable during facility planning of specific CSO control technologies. By understanding the chemical characteristics of the industrial wastewater potentially present in CSOs, the city will be better able to evaluate and design site-specific CSO controls. Data evaluated to identify and quantify industrial discharge characteristics included:

- List of SIUs and permit numbers matched to first potential receiving CSO, prepared by United Water, formerly White River Environmental Partnership (WREP).
- Industries Flow Information Report of July 14, 2004, detailed by process flow, sanitary flow, and cooling flow. The calculations in this analysis were based on process flow from industries meeting the definition of "significant industrial user" as defined in 40 CFR 403.
- White River Environmental Partnership, Belmont AWT Laboratory, Industrial Monitoring Report, Aug. 6, 2004. This report includes compliance data and self-monitoring data. Only values for zinc were used from this report. The report is sorted based on permit number.

Data from the above documents and databases was used to characterize the individual SIU discharges. The city then developed a potential toxicity ranking of individual CSOs using the following approach:

1) **Associate SIUs with CSOs:** The city identified all SIUs associated with each CSO, assuming all the potential SIU effluent discharges from the first potential receiving CSO.

2) Toxic Effluent Characterization: The city identified average toxic effluent concentrations (in parts per million) associated with each SIU. Concentrations are based on an average of all effluent samples taken by United Water during the year 2004. At least two effluent samples were taken from each SIU during this time period. These data were then used in a preliminary screening analysis to identify which SIUs would likely contain the most significant concentrations. Using toxic weighting factors, those SIUs having an apparent aggregate discharge concentration higher than 1 mg/L were then subjected to a more detailed analysis using averages from a broader base of data, such as from monthly reports of operation, over the same time period.

3) Sum of Weighted Toxics: The city normalized SIU average effluent characteristics using U.S.EPA Toxicity Weighting Factors (see **Table 2-20**); and summed normalized effluent data to represent an overall toxicity value.

4) Significant Industrial Concentration (Criterion 1): The likely "toxic weighted" concentration computed for each industrial user was then converted to a flow-weighted concentration in the aggregate of the industrial flows for a given CSO location. The resultant values were then ranked from 1 to 5 based on the priority rating footnoted in **Table 2-21**. Domestic sewage is also a recognized source of most of the toxic constituents listed in **Table 2-20**. Using national averages reported by U.S. EPA, domestic sewage would have a "toxic weighted concentration" of about two to three. Therefore, total volume of CSO discharge is another important criterion for ranking of potential toxic sources.

5) Significant Industrial Flow Percentage (Criterion 2): The likely industrial flow contribution relative to the total flow was computed as the ratio of the aggregate industrial flow component (using annual average flow data for each of the industries) to the estimated total carrying capacity of the CSO outfall. The ratios were then grouped into five categories and assigned values of one to five, with five as the highest priority. Definitions for each ranking are footnoted in **Table 2-21**.

6) Frequency of Overflow Events (Criterion 3): The likely frequency of CSO outfall activation was based on recorded data and modeled estimates. Modeled simulations using precipitation data from 1950 – 2003 indicate, for example, that CSO 008 near the Belmont plant activates a maximum of about 70 days per year, whereas CSO 003 near the Southport plant activates much less frequently; about seven days per year. The overflow frequencies for the remaining CSO outfalls were based on the frequency data previously presented in Table 2-8 of the "Indianapolis CSO LTCP Hydraulic and Water Quality Modeling Development Report" (Department of Public Works - Indianapolis Clean Stream Team (DPW-ICST), 2004). Like the other criteria, the frequency data were grouped into five categories and assigned values of one to five with five the category of highest frequency.

The average of the three criteria were used to rank CSO outfalls for their potential to discharge toxics into receiving streams in the CSO area. Based on this methodology, **Table 2-21** lists 20 Indianapolis CSOs that scored an average of 0.7 or greater on a 1-to-5 scale. **Table 2-21** also includes individual criterion ratings for each CSO, and their receiving water and general location. The location and potential toxic characteristics of these CSOs will be used to identify, prioritize, and design specific CSO control projects during the facility planning stage of implementing the LTCP.

Table 2-20
Toxic Weighting Factors for Elements Present in SIU Effluents

Weighting Factor	Toxic Weight
Ammonia-N - 252	0.0037
Antimony	0.1900
Arsenic	4.0000
Cadmium	5.2000
Chromium	0.0267
Copper	0.4700
Cyanide - total	1.0800
Cyanide, amendable to chlorination - 257	1.0800
Lead	1.8000
Mercury	500.0000
Nickel	0.0360
Phenolics High Level, 4AAP - 267	0.0280
Selenium	1.1000
Silver	47.0000
Zinc	0.0510

Reference: U.S.EPA, 1995, FLI Assessment of Compliance Costs, Table 4-1 and updated by U.S.EPA Region V in 1997

2.10 Sensitive Areas Analysis

U.S. EPA's National CSO Control Policy and Indiana CSO Strategy identify elimination, relocation or control of CSO discharges to sensitive areas as being the highest priority requirement for the development of the long-term control plan. Sensitive areas are waters impacted by CSO discharges that must be given the highest priority for CSO discharge elimination, relocation, or control. Sensitive areas include:

- Waters with threatened or endangered species and their habitat
- Waters supporting primary contact recreation (e.g., bathing beaches)
- Public drinking water intakes or their designated protection areas

Table 2-21
Ranking of CSOs that Could Contain Toxics from Industrial Users: Future Conditions

CSO	No. of SIUs for this CSO	Average of Criterion Ratings	Criterion 1 Likelihood of Significant Industrial Concentration		Criterion 2 Likelihood of Significant Industrial Flow Percentage		Criterion 3 Likelihood of Overflow Events		Receiving Water	Location
			Computed toxic equivalent concentration (mg/L)	Rating	Percent of capacity of sewers leading to CSO outfalls	Rating	Estimated number of overflow events per year (maximum)	Rating		
003	20	2.0	0.684	2	5.333	2	4	2	White River	Southport Plant
117	2	2.0	3.59	3	1.305	1	4 *	2	White River	Southern Avenue & White River
074	2	2.0	6.01	4	0.561	0	4	2	Pleasant Run	PLRPND & Prospect Street
135	1	2.0	5.787	4	0.003	0	4	2	Fall Creek	Orchard Avenue & 39th Street
008	17	1.7	0.127	2	3.038	1	4 *	2	White River	Belmont Raw Wastewater Overflow
011	1	1.7	0.575	2	1.621	1	4	2	Eagle Creek	Minnesota Street and Pershing Avenue
051	5	1.7	1.917	3	0.039	0	4	2	Fall Creek	Capital Avenue & 22nd Street
150	1	1.3	0.685	2	0.372	0	4	2	Pleasant Run	PLRPND & Raymond Street
A38	3	1.3	0.318	2	0.372	0	4	2	Pogues Run	Davidson Street & Washington Street
120	2	1.3	0.123	2	0.261	0	4	2	Pleasant Run	343 W. Southern
065	3	1.3	0.222	2	0.099	0	4	2	Fall Creek	Sutherland Avenue & 34th Street
076	1	1.3	0.835	2	0.052	0	4	2	Pleasant Run	PLRPND & English Avenue
049	1	1.3	0.62	2	0.023	0	4	2	Fall Creek	Stadium Drive & Fall Creek
080	1	1.3	0.618	2	0.020	0	4	2	Pleasant Run	PLRPND & Wallace Avenue
075	1	1.3	0.612	2	0.007	0	4	2	Pleasant Run	PLRPND & Southeastern Avenue
062	2	1.3	0.029	2	0.005	0	4	2	Fall Creek	Guilford Avenue & 30th Street
152	2	1.3	0.692	2	0.002	0	4	2	Pogues Run Tunnel	Pine Street & Ohio Street
034	1	1.3	0.023	2	0.000	0	4	2	Pogues Run	Michigan Street & Dorman Street
092	3	1.0	0.474	2	1.053	1	<1	0	Pleasant Run	PLRPSD & Ridgeview Drive
032	1	0.7	0.083	2	0.174	0	<1	0	Eagle Creek	Morris Street & Warman Avenue

* Individual overflow frequency estimates for CSO 117 and 008 are presented within the same range (67-70 events per year.) Overflow frequency at CSOs 117 and 008 is dependant on manual operation of the Southwest Diversion Structure.

Priority Rating System

Criterion 1 Likelihood of Significant Industrial Concentration	Criterion 2 Likelihood of Significant Industrial Flow Percentage	Criterion 3 Likelihood of Overflow Events	Priority Rating	Description
10.1 - 100	61 - 100%	> 50 events/yr.	5	Most significant
5.1 - 10	21 - 60%	21 - 50 events/yr.	4	Moderate
1.1 - 5	11 - 20%	11 - 20 events/yr.	3	Modest
0.011 - 1.00	5 - 10%	1 - 10 events/yr.	2	Minimal
< 0.01	1 - 5%	1 event/yr.	1	Insignificant
0	< 1%	< 1 event/yr.	0	No impact

- Outstanding State Resource Waters or Outstanding National Resource Waters

The EPA's CSO Control Policy states, that for sensitive areas, the LTCP should:

1. prohibit new or significantly increased overflows;
2. eliminate or relocate overflows that discharge to sensitive areas:
   a. wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment, or;
   b. where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, provide the level of treatment for remaining overflows deemed necessary to meet water quality standards for full protection of existing and designated uses;
3. where elimination or relocation has been proven not to be physically possible and economically achievable, permitting authorities should require, for each subsequent permit term, a reassessment based on new or improved techniques to eliminate or relocate, or on changed circumstances that influence economic achievability.

The city's sensitive area analysis is documented below.

2.10.1 Recreational Use Data

Although the water quality of Marion County streams is not suitable for recreation and recreation is prohibited by ordinance, some recreational uses do occur. The city has collected extensive data about recreational uses occurring along CSO-impacted streams, as presented below.

2.10.1.1 Prohibited Uses

City ordinance prohibits swimming in most waterways in Marion County, including all streams in the combined sewer area. The ordinance states, "It shall be unlawful for any person to fish, bathe, wash, operate boats in or enter any public waterways, or to send, drive or ride any animal into any public waterways, where not authorized for such purposes." (Code 1975, Sec. 7-21). A separate ordinance passed by the Health and Hospital Corporation of Marion County states that public swimming or wading beaches "shall not be located in areas subject to pollution by sewage" (Gen.Ord. 8-1996(A)).

2.10.1.2 Reported and Observed Uses

Although prohibited by ordinance, some citizens use portions of the White River and its tributaries for fishing, canoeing, kayaking, wading, and occasional swimming. As demonstrated earlier in Section 2.2, the low-flow nature of most streams in the combined sewer area is not conducive to full-body contact, with the exception of the White River. Section 2.4 also demonstrated that water quality conditions in CSO-impacted waterways do not support swimming, particularly following wet weather events. Yet these activities occur despite the city's public notification program and signs posted along the streams by the Department of Public Works and the Marion County Health Department, warning citizens to avoid contact with streams in the CSO area because of sewage pollution.

As part of developing the long-term control plan and use attainability analysis, the city has identified how and where people use the streams. This information was used by the city to prioritize and schedule CSO control projects. In public meetings and a non-random face-to-face survey, the city asked people to report how they use or have seen others use the waters. As one might expect, recreational uses occurred primarily in dry weather or after light rainfall events.

During the information-gathering stages of the research, the team used the following definitions:

- **Swimming:** ***Full-body contact*** with the water, including a ***high potential for swallowing*** the water (water should be deep enough to permit actual swimming).
- **Water Skiing/Jet Skiing:** Water skiing, jet skiing, tubing or other recreational boating ***activities that carry a high potential for full-body contact*** with the water (falling or jumping into the water).
- **Wading**: ***Partial body contact*** with the water (usually water contact to lower legs and possibly hands and arms).
- **Playing at the Stream Bank:** Kneeling, squatting or sitting at stream bank (***some water contact may occur*** when hands reach into the water to touch or pick up something).
- **Fishing:** Fishing at the stream bank or from a boat (water contact occurs through handling fish and tackle).
- **Boating:** Recreational boating that involves little or no water contact.
- **Canoeing:** Recreational canoeing that may involve some water contact upon entry or exit, or through contact with paddles, etc.
- **Kayaking (whitewater):** Recreational kayaking that involves navigating whitewater areas and/or significant

potential for water contact from frequent kayak overturn movements.

Results of the city's additional research into recreational use activities are presented below. Sources of information used by the city included:

- Physical stream survey in May-July 2001
- Public non-random intercept survey in June 2002
- Public outreach meetings with neighborhoods and environmental/recreation groups in September-November 2002
- Marion County Health Department reports from 2001-2002
- Indy Parks stream use survey in October 2002
- Survey of downstream communities and agencies.

The following is a description of the data gathering methodology for each data source:

Physical Stream Survey: Survey teams walked each water body and viewed aerial videos to determine the physical characteristics that encourage or discourage water use. Teams would note areas of easy access to the water as well as dense vegetation, steep slopes, or infrastructure that discourages water contact. Streams were walked from late May 2001 to early July 2001. An aerial videotape of Marion County streams was taken on April 1, 2002. A video of White River downstream of Marion County was taken in January 2003. The survey teams walked along the water bodies to identify any recreational areas where primary water contact could occur within the CSO areas, as well as indications of use such as graffiti on bridge structures. The physical stream survey also noted locations of use based upon actual observations.

The city selected this period for the survey because children were out of school for summer and the weather was warm. The temperature was generally above 75 degrees Fahrenheit, and most days the temperature was above 80 degrees. The city assumed that warm weather would encourage use in and along the streams. The team conducted the physical stream survey between 9:00 am and 5:00 p.m. on weekdays.

Public Outreach Surveys: The city conducted public outreach surveys in June 2002 to gather information about activities that occur near and in the water by people who use the water bodies or nearby corridors, and their reports of current and historical observed usage of the streams. The team surveyed walkers, joggers, residents and child-centered organizations along the White River, Fall Creek, Eagle Creek, Pleasant Run, and Pogues Run to learn where and how often water contact occurred within the areas prone to sewage overflows. One hundred people were surveyed along each stream. The surveys were non-random intercept personal interviews. According to those interviewed, the primary usage of all the streams in Indianapolis is walking, jogging, and biking along the water or nearby corridors. The primary activity involving water contact is fishing, followed by playing at the stream bank. The respondents said that the uses have not changed over the past two decades; however, most respondents were between the ages of 18-29. The majority of respondents also observed infrequent and inconsistent recreational usage within 24 hours after a rainfall.

The city, in consultation with regulatory agencies and advisory committees, developed a 10-question survey that was consistently followed by a team trained to implement the questionnaire.

These surveys had several limitations that must be considered in using and interpreting the data:

- **The results cannot be extrapolated to the city's general population.** The survey was not conducted using random sampling, nor is the sample size large enough to warrant extrapolation of the results to the general population.
- **The goal of the recreational use study was to survey people who recreate near the water to determine their opinions.** The methods described below were specifically designed to skew results toward finding people who do or are most likely to use the water, at a time when water use is at its highest levels. Respondents were members of environmental or recreational organizations, church groups and childcare providers within a mile of a water body; citizens encountered while they were walking, jogging or biking along a stream; and residents living on or within a mile of a water body.
- **The targeted population is not similar to other segments of the population who were not surveyed**. It is expected that other segments of the population would use the waters less frequently than those surveyed. A 1999 telephone survey that used a random, representative study population suggests that stream use occurs significantly less frequently among all residents of Marion County. In this survey 89 percent of respondents said that they never swim in Marion County waterways (margin of error $\pm$5 percent). This question did not distinguish between waterways affected by combined sewer overflows and those not affected by CSOs.

Public Outreach Meetings: The Department of Public Works (DPW) conducted additional public outreach meetings from September through November 2002 to add to information gathered on stream use. The Department of Public Works partnered with neighborhood associations and environmental groups in Indianapolis to host public meetings to gather information about stream use by those most likely to use the water in the city. The survey questions and definitions were the same as those used in the public outreach survey; however, the method of question delivery was to a group, not a personal interview.

MCHD Public Access Stream Sampling Information: The MCHD samples water bodies for *E. coli* and macroinvertebrates. Some sampling sites are based on where stream activities have been reported to MCHD by the public. The sites and activities identified by the public in 2001-2002 also were included in the stream use survey results.

Indy Parks Stream Use Surveys: In late 2002, the Department of Public Works surveyed eight employees of the Indy Parks system who work closest to the water bodies. The survey was a modified version of the stream use questionnaire and supplemented the reported uses found in the other surveys.

Downstream Agency Survey: In late 2002, the Department of Public Works mailed a survey to downstream agencies, including county health departments, parks departments, county offices, McCormicks Creek Stake Park, and the Department of Natural Resources headquarters in Districts 5-7. IDEM reviewed this survey form and appropriate comments were incorporated before distribution the week of October 6, 2002. Instructions accompanying the survey requested that each recipient utilize one staff person who was familiar with recreational uses of the White River in the area to answer or compile the information from others. The city requested that the survey be returned October 31, 2002.

Detailed results of these surveys and the city's research into recreational uses in CSO-impacted waterways can be found in "Recreational Use and Stream Characteristics" (DPW-ICST, April 2004). A brief description of the results for each stream is provided below.

2.10.1.2.1 Fall Creek

Appendix A8 illustrates the reported and observed recreational uses involving water contact along Fall Creek, based upon the above data sources. North of 30th Street, where access is more limited, some fishing and playing at the stream bank is reported. Wading is reported at 30th Street and Fall Creek Park, particularly when children wade into the creek to retrieve basketballs from the basketball courts there. Fishing and playing by the stream bank also are reported at locations from 30th Street to Martin Luther King Jr. Drive. Wading is reported upstream of the Boulevard dam, a popular fishing location, and at Watkins Park. Fishing is the dominant activity downstream of Watkins Park, with playing at the stream bank reported at Fall Creek & 16th Park and along the floodplain near the confluence with White River.

2.10.1.2.2 Pleasant Run and Bean Creek

Appendix A9 illustrates the reported and observed recreational uses involving water contact along Pleasant Run and Bean Creek. Recreational uses on Pleasant Run are found predominantly along the many parks and greenways located along this low-flow, neighborhood stream. Wading and playing by the stream bank is reported at various spots along the greenways, including Pleasant Run Golf Course, Ellenberger Park, Christian Park, and Garfield Park. Fishing also is reported, although the fishing in this small stream involves hunting for crayfish rather than traditional sport fishing. Swimming is reported in three locations, although streamflows are too low to support full-body contact along most of Pleasant Run. One small swimming hole was reported on Pleasant Run downstream of Prospect Street and another along Bean Creek near Keystone Avenue. A third reported swimming hole, between Meridian and Bluff, is believed to refer to a gravel pit just north of Pleasant Run; Pleasant Run is normally too shallow to support swimming.

2.10.1.2.3 Pogues Run

Similar to Pleasant Run, reported and observed recreational uses along Pogues Run are found predominantly along parks and greenways, as shown in **Appendix A10**. Playing by the stream bank and wading are reported along much of the stream, including in Forest Manor Park, Brookside Park, Spades Park and at the downstream end before Pogues Run enters the tunnel that carries it under downtown Indianapolis. Pogues Run flows through several Indianapolis Public Schools campuses south of 10th Street; playing by the stream bank is reported in this area. Fishing for crayfish is reported in Brookside Park and Spades Park. Occasional full-body contact (swimming) is reported in two locations, one within Brookside Park and one in Spades Park, although normally Pogues Run is too shallow for full-body contact activities.

2.10.1.2.4 Eagle Creek

Appendix A11 illustrates the reported and observed recreational uses involving water contact along Eagle Creek. Unlike Fall Creek, Pleasant Run and Pogues Run, Eagle Creek does not flow through city parks and greenways. Nevertheless, recreational uses involving water contact are reported along this waterway. Fishing, wading and playing by the stream bank are reported on both Big Eagle Creek and Little Eagle Creek within the CSO area. Despite the lack of parks and public access, swimming is reported in at least nine locations along Eagle Creek in the CSO area. Some of these locations are adjacent to trailer parks where children's pools were prohibited, according to residents interviewed by survey teams. A variety of factors may cause the increased reports of swimming in Eagle Creek: relatively good water quality compared to other streams, lack of public swimming pools or splash areas in the area, and cultural acceptance within the neighborhood of swimming in a natural stream.

2.10.1.2.5 White River (Marion County)

Appendices A12a through **A12d** illustrate reported and observed recreational uses involving water contact along White River as it flows through Marion County.

Appendix A12a illustrates reported and observed activities at the upstream end of White River's CSO-impacted area, downstream of Broad Ripple Park. At the time the survey was taken, there was a lone CSO upstream of Holliday Park on the city's north side. That CSO has since been eliminated. The first recreational uses reported downstream of an existing outfall are found in the Rocky Ripple neighborhood, where fishing, wading, playing by the stream bank and canoeing are regular activities. Swimming also is reported in the Rocky Ripple neighborhood along Ripple Road, though primarily by one individual and his family. Recreational uses, including occasional swimming, also are reported near the Butler University campus and by the Indianapolis Museum of Art. Swimming near the art museum is reported to occur mainly in a pond known as the "Blue Lagoon," which is adjacent to the river on the art museum property. Fishing and canoeing occur throughout this stream reach.

Appendix A12b illustrates reported and observed activities along White River from 38th Street to New York Street. At the upstream end of this stream reach, the river is bounded by several city parks and golf courses; fishing, canoeing and playing by the stream bank are reported here. There is a city boat launch in Riverside Park; historically, water skiing occurred in this area, known locally as Lake Indy. Downstream of the 16th Street dam the most frequent reported use is fishing, although canoeing, wading and playing by the stream bank also are reported along White River State Park downstream of the river's confluence with Fall Creek.

Appendix A12c illustrates reported and observed activities along White River from New York Street to the Belmont AWT plant. The river is less accessible within this reach, and therefore fewer uses are reported. Pockets of reported uses occur at access points just south of Washington Street, at Raymond Street and near Harding Street. Fishing is the predominant activity in this area, although wading, playing by the stream bank, canoeing and boating also occur.

Appendix A12d illustrates reported and observed activities along White River from the Belmont AWT plant to the Southport AWT plant. Fishing is the predominant use in this more industrialized area, although canoeing, wading and playing by the stream bank also are reported in some locations where the public can gain access to the river.

2.10.1.2.6 White River (Downstream of Marion County)

In October 2002, DPW sent written survey instruments to downstream county health departments, parks departments and government offices in Daviess, Greene, Johnson, Knox, Morgan, and Owen counties. Surveys also were sent to McCormick Creek State Park, as well as the Department of Natural Resources Headquarters in Districts 5-7. Nine completed surveys were returned and included in the city's database.

Appendix A13 illustrates the reported and observed activities along White River from the downstream survey. Recreational uses appear to be clustered around public access points, shown as green dots in **Appendix A13**. The predominant reported uses include fishing, boating, canoeing, playing by the stream bank, and wading. Swimming also is reported near McCormick Creek State Park and at Bloomfield. However, the city knows of no public swimming beaches along the river within this area. Downstream from Bloomfield land use is primarily agricultural and fewer water contact recreational uses were reported to the city.

2.10.1.2.7 Recreational Use Conclusions

Based upon the data gathered, the city drew the following conclusions:

- A range of recreational activities are reported to occur all along waterways throughout the CSO area.
- Swimming by a small number of people is reported in a few locations, although prohibited by ordinance. Few areas on tributaries are deep enough to accommodate swimming.

- The non-random intercept survey along CSO-impacted streams shows that the most popular recreational activities are walking/jogging/biking along the waterways, followed by boating/canoeing and fishing; less popular activities are playing at the stream bank, wading and swimming.
- According to follow-up meetings and surveys, full-body contact activities occur with some frequency in the Rocky Ripple area on the White River and on Pleasant Run near Meridian and Bluff. The number of users is small and uses are found during dry weather or after small storm events that would be controlled by this plan. Full-body contact activities are reported to occur less frequently on other streams. Again, the number of users is small.
- Partial body contact activities are reported to occur on a number of streams. Both children and adults are reported to engage in these activities. More adult use than child use is reported.
- Downstream of Marion County, minimal in-stream recreational activity was reported from the Marion County line to south of Waverly.
- Reports of recreational activity in and around the river begin to increase south of Waverly, with fishing along the river being the most commonly reported activity. Most observed uses are reported south of Gosport.
- Uses are often found in parks and at public access points. However, a lack of parks in residential areas may lead to more stream use, such as on Eagle Creek.
- Cultural norms in a neighborhood can be a key factor influencing use. What may be an accepted recreational stream activity in one neighborhood may be unacceptable in another, due to cultural differences.
- Full-body or partial-body contact activities (although limited) are reported at the most downstream reaches of CSO-impacted streams, and numerous high-volume CSO outfalls are located at the upstream ends of these streams.

It is apparent that individual stream segments have value to the neighborhoods and residents who use them and live along them. However, based on the data gathered by the city, it appears that no one area has obviously superior value to the overall community than any other area along these waterways.

2.10.2 Outstanding State Resource Waters

The city contacted the Indiana Department of Natural Resources (IDNR) to discuss Outstanding State Resource Waters. On May 14, 2001, IDNR sent a letter confirming that there are no Outstanding State Resource Waters in Marion County. Downstream of Marion County, the White River is not an Outstanding State Resource Water.

2.10.3 Threatened or Endangered Species

To date, no state or federal threatened or endangered species have been identified that are being impacted by CSOs. The city contacted the IDNR and the U.S. Department of Interior's Fish and Wildlife Service (USFWS) to obtain information on threatened or endangered species, including their habitat.

On May 14, 2001, IDNR forwarded data sheets and a map showing the location of threatened or endangered species in Marion County. After receiving the information, city representatives contacted three specialists at IDNR to discuss the habitat of species shown near the waterways:

- Brant Fisher, a non-game aquatic biologist with the Division of Fish and Wildlife, confirmed that there are no threatened or endangered fish or mussels in Marion County.
- Ron Hellmich, data manager with the Division of Nature Preserves, stated that the Virginia Bunchflower was observed near the upper White River at Crows Nest in 1913. While it does not grow in the water, it does inhabit wet woods and meadows of flood plains. Mr. Hellmich also stated that a survey has not been done since 1913 and he is not sure the flower or the habitat to support the flower still exists.
- Katie Smith, non-game supervisor with the Division of Fish and Wildlife, stated that the Kirtland Snake does not live in or around water. This reptile is small, eats earthworms, and prefers to live under rubble.

On July 30, 2001, the USFWS forwarded information that indicated the endangered and threatened species found in central Indiana are the bald eagle and Indiana bat. The reintroduction of the bald eagle in Indiana has been a resounding success. The most recent Midwinter Bald Eagle Survey, conducted by the IDNR in January 2004, counted 124 bald eagles, two golden eagles, and one unidentified eagle. The 10-year average for the midwinter count is 157 eagles. Bald eagles are found along the West Fork of the White River, from its confluence with the Wabash River to north of Marion County. While eagles are dietary generalists, the primary diet for bald eagles is fish, so bald eagles tend to nest in undeveloped forested area along rivers and lakes. Most of the bald eagles counted during the midwinter survey were found along rivers. The 10-year average for the midwinter count indicates that 69 percent of the bald eagles in Indiana have been counted along rivers (IDNR, 2004). The eagle population fell in the 1950s and 1960s, when the eagles consumed fish that had bioaccumulated toxic chemicals. As these toxins were banned and IDNR reintroduced eagles to the state, the bald eagle population began to recover (IDNR, 2004). As the City of Indianapolis implements its long-term control plan, water quality conditions along the White River will continue to improve eagle habitat. In 2004, bald eagles were seen nesting in Marion County for the first time in many years.

The Indiana bat has not been as successful as the bald eagle. Indiana bats hibernate in caves in winter and disperse to breed and forage in spring and summer, typically in undisturbed forests along streams and lakes. The USFWS reports that there are current records for the Indiana bat in the Fall Creek watershed (USFWS, 2001). According to the USFWS, the most promising habitat would be from 56th Street to Geist Reservoir, upstream of the CSO area.

2.10.4 Public Drinking Water Intakes

Combined sewer outfall 103 flows into Meadow Brook, a tributary of Fall Creek. Meadow Brook's confluence is just upstream of Indianapolis Water's Fall Creek intake at Keystone Avenue. The city plans to eliminate overflows at CSO 103 by the end of 2007 through sewer separation and other projects.

2.11 Summary

The White River basin is part of the Mississippi River system and drains 11,349 square miles of central and southern Indiana. Marion County accounts for about 36 percent of the 2.37 million people living in the basin.

From the turn of the century through the mid to late 1970s, published reports have documented extremely poor water quality conditions in the White River due to inadequate wastewater treatment, industrial pollution, and sewage overflows.

Land use in the Indianapolis area is primarily urban. A 1998 U.S. Geological Survey study concluded that urban areas were responsible for degradation of stream water quality in Indianapolis. Outside of Marion County, agriculture is the predominant land use within the White River basin. Pesticides are commonly detected in waters within the basin, particularly following rain events during the application season. Bacteria associated with animal feedlots also are found in the White River as it enters Marion County.

The West Fork of the White River and its two largest tributaries, Fall Creek and Eagle Creek, are the major sources of water for public and industrial supply in Indianapolis. Streamflow in the White River and its tributaries is highly variable and related to precipitation. Flow is generally highest in late winter and early spring. Both high and low streamflows can significantly affect water quality. A physical survey of CSO-impacted waterways in 2001 documented streamflow, depth, substrate and accessibility information, which was used by the city to identify possible opportunities for and obstacles to recreational use in these waterways. Accessible waterways include Upper White River, Pleasant Run, Pogues Run and Fall Creek, although people can gain access to Eagle Creek and lower stretches of White River.

The City of Indianapolis owns and oversees management of the wastewater collection system serving most of Marion County. Both combined and sanitary sewers carry wastewater to three interceptor branches and a centrally located core interceptor sub-network. These interceptors carry wastewater to two advanced wastewater treatment facilities, the Belmont and Southport plants. The combined sewer area, which is located primarily in the older sections of the City of Indianapolis, contains 132 combined sewer outfalls. Outside the combined sewer area, most neighborhoods are served by separate storm and sanitary sewers. However, an estimated 30,000 properties are served by private septic systems. About 95 square miles remain undeveloped and unsewered, including areas in Franklin, Pike, Washington, Decatur and Wayne townships.

Water quality in Marion County has improved significantly since the passage of the Clean Water Act, yet Indianapolis faces many remaining challenges to achieving water quality goals. Although combined sewer overflows are the largest pollution contributor, other sources are responsible for water quality violations, including urban stormwater, leaching septic systems, and upstream pollution sources.

Further, a number of systemic conditions prevent the attainment of recreational use standards in Indianapolis waterways, including the urban character of Marion County, low-flow conditions in many streams, and waste from pets and wildlife.

Studies of Indianapolis waterways and the combined sewer system have resulted in the following key findings:

- Fall Creek and the White River do not meet the dissolved oxygen standard during some rain events. The problem can be severe enough to cause fish kills.

- CSO receiving streams in Marion County have never supported the full-body contact recreational use. IDEM's 2002 and proposed 2004 303(d) lists of impaired waters in the State of Indiana identify White River, Fall Creek, Eagle Creek, Pleasant Run, Pogues Run, Bean Creek, and State Ditch as being impaired for *E. coli* bacteria. Even streams that are not affected by CSOs are listed as impaired for *E. coli,* including Dollar Hide Creek, Fishback Creek, and Mars Ditch.
- Significant sources of *E. coli* bacteria are found in stormwater runoff. Factors contributing to stormwater bacteria include leaching septic systems, illicit connections to the storm sewer system (including many related to septic systems), urbanization, and domestic animals and wildlife.
- The city has analyzed effluent data from industrial users to rank and prioritize CSOs based on the theoretical potential for significant industrial discharges to enter streams during wet weather events. Although this analysis is theoretical in nature, it can be used during facility planning to identify, prioritize and design specific control projects that will minimize industrial impacts on the receiving streams.

Neither the water quality nor the depth and flow of streams in the CSO area is conducive to full-body contact recreation. A city ordinance prohibits swimming in non-designated waterways in Marion County, including all streams in the combined sewer area. A public notification program and signs posted by the Department of Public Works and Marion County Health Department warn citizens to avoid contact with streams in the CSO area due to sewage pollution.

Nevertheless, water recreation activities by a small number of people are reported throughout the CSO area and downstream of Marion County. Full-body or partial-body contact activities (although limited) are reported at the most downstream reaches of CSO-impacted streams, and numerous high-volume CSO outfalls are located at the upstream ends. While individual stream segments have value to the neighborhoods and residents who use them and live along them, it appears that no one area has obviously superior value to the overall community than any other area along these waterways.

There are no outstanding state resource waters or threatened or endangered species affected by Indianapolis CSOs. One combined sewer outfall discharges into Fall Creek upstream of Indianapolis Water's municipal intake at 38th Street and Fall Creek Parkway. This CSO will be eliminated by the end of 2007.

An integrated, watershed-wide effort is necessary to achieve the ultimate water quality goals in Indianapolis. The City of Indianapolis wants to ensure that affordable investments in water pollution control will yield the greatest benefit possible for human health, the environment and the citizens who live in Marion County.